THE HOPE REPORTS

VOL. II

1897—1900

EDITED BY

EDWARD B. POULTON, M.A., D.Sc., F.R.S.

Hon. LL.D. Princeton

FELLOW OF JESUS COLLEGE, OXFORD

HOPE PROFESSOR OF ZOOLOGY IN THE UNIVERSITY OF OXFORD

Oxford

PRINTED FOR PRIVATE CIRCULATION

BY HORACE HART, PRINTER TO THE UNIVERSITY

1901

THE MAKERS OF THE HOPE DEPARTMENT
OXFORD UNIVERSITY MUSEUM

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PREFACE

THREE and a half years have elapsed since the first volume of the Hope Reports was issued, in June 1897. During this period the materials for the second volume have been gradually accumulating, representing certain important sides of the work done in the Department, or upon portions of its collections which have been removed for study and comparison with those of other museums. I had hoped that this second volume would have been ready in a somewhat shorter time, but other sides of our work have prevented an earlier appearance. The Reports of the Department for the years 1897, 1898, and 1899 (Nos. 21, 22, and 23) sufficiently indicate the nature of this work, and prove that much labour has been expended upon the manipulation, naming, and systematic arrangement of this vast collection, together with the numerous accessions due to the kindness of naturalists in many parts of the world. A large amount of cataloguing and the printing of many thousands of labels have also been rendered necessary by the new material. Furthermore, a considerable proportion of the papers in this volume are abstracts of much longer and more detailed memoirs, many of which are far advanced towards completion. This is the case with the papers of which Nos. 4, 7, 8, 9 and 10 are abstracts: these, when published, will contribute an important share to the third volume of the Hope Reports.

The contents of this volume have been arranged according to their subjects, the first ten papers (omitting 3 c) being almost exclusively concerned with Mimicry, Warning Colours, and the Struggle for Existence in Insects, Nos. 10 to 13 with seasonal dimorphism, and the colour of pupae, &c., as influenced by the surroundings of the larvae, No. 14 with Hybridisation, No. 14 A with the 'Organic Selection' of Baldwin, Lloyd-Morgan and Osborn, Nos. 15 to 19 with systematic work upon parts of the existing Hope Collection or new material which has recently been added. It should be noted that Mr. Champion's paper on the *Tingitidae*, No. 15, is founded on the study of material from many collections: it is included here because a large proportion of the types of the new species described are in the Hope Museum. Nos. 3 c and 20 deal with the manipulation and labelling of insects for collections, while Nos. 21 to 23 are the Reports of the Hope Professor for the years during which the materials for this volume have been accumulating. I venture to hope that the contents of the volume indicate some activity and energy in the Department. Great encouragement has been received from the manner in which naturalists in many countries have looked to the Hope Museum as a centre for the study of insect bionomics, and have sent material bearing on these difficult and deeply interesting problems to Oxford. When the specimens now rapidly accumulating have been arranged, the student will have unique opportunities for the study of Mimicry, Warning Colours, Protective Resemblance, and allied questions. Nor will the arrangement be long delayed, for the chief part of the printing, labelling, cataloguing, and preliminary grouping has already been done.

One chief duty of our ancient University is to contribute its share, and may it be a very large one, towards winning

fresh territories from the unknown. This Department would not be doing its duty to the University, to the memory of its Founder, and to that of the first Hope Professor, if some advance were not made in that part of the boundaries of knowledge which stands opposite to it. I would that every College, and every University department, felt this responsibility as keenly as it is felt in a happily increasing number of Oxford laboratories and scientific departments. I do not wish to be misunderstood in making these high claims for the exponents of the natural and physical sciences. Our scientific men are fighting side by side with the Oxford students of other branches of learning. The interests of the ancient studies in Oxford are sometimes supposed to conflict with the more modern. But the real contest is between those who would and those who would not devote their energies to widening the boundaries of knowledge, and there can be nothing but comradeship and the warmest sympathy among the men whose keenest efforts are put forth in order that Oxford may be known far and wide as a centre of research and learning.

EDWARD B. POULTON.

HOPE DEPARTMENT OF ZOOLOGY,
UNIVERSITY MUSEUM, OXFORD,
January 4, 1901.

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XIII. *Mimetic Attraction.* By FREDERICK A. DIXEY, M.A., M.D., F.E.S., Fellow of Wadham College, Oxford.

[Read May 5th, 1897.]

PLATE VII.

IN a former contribution* to the Transactions of this Society, I endeavoured to trace, by means of actual examples, the successive steps through which a complicated and practically perfect mimetic pattern could be evolved in simple and easy stages from a form presenting merely the ordinary aspect of its own genus. In the present paper I propose to enter somewhat further into the subject of mimetic change, and in the first place to show how the process of gradual assimilation, starting from one given point, may take not one direction only, but several divergent paths at the same time; in other words, how the members of a single group may assume several different mimetic developments, each one corresponding to a distinct model, but all derived by easy stages from the same original form.

In the paper just referred to it was shown that a very complete transition could be demonstrated, by means of closely-allied and still existing species, between an ordinary *Pieris* such as *P. phaloe*, presenting only the usual features of its genus, and a form of such widely different aspect as *Mylothris pyrrha* ♀; the latter being a nearly exact copy of *Heliconius numata*. But although these facts are sufficiently striking, it is perhaps still more remarkable that from the same or closely allied and very similar forms of typical Pierine aspect, at least four other lines can be traced, each showing almost as perfect a transition as that from *P. phaloe* to *M. pyrrha*, and each leading up to a presumably distasteful model; these models being in appearance entirely different from *H. numata* and from each other.

* "On the Relation of Mimetic Patterns to the Original Form," Trans. Ent. Soc. Lond. 1896, pp. 65–79, pls. III.–V.

A full illustration of this position would require a larger series of diagrams than could well be given in this place; it is hoped, however, that the series of figures on Plate VII. may suffice to show the more important links in each chain, or at any rate to make the drift of my statements intelligible. It should be borne in mind that all the forms here spoken of are neotropical.

1. *The "agna" line.* The first of these lines of development may be called the *agna* line, inasmuch as it leads towards a well-marked group of distasteful forms of which *Aeria agna*, Godm. and Salv., (Pl. VII., fig. 6) is a good example. Starting from a white *Pieris* of ordinary aspect like *P. phaloe,* we find that the first step in the growth of this mimetic pattern is furnished by the prolongation of the diagonal dark bar, which in *P. phaloe* ♀* extends from the costa to the distal end of the cell in the forewing, to meet the dark hind margin as in *P. calydonia* ♀ (fig. 1, *k*). All stages in the development of this first feature can indeed be traced by comparing specimens of both sexes of *P. calydonia* itself. The next step is the extension of the dark hind border of the forewing, already more pronounced in *P. calydonia* ♀ than in *P. phaloe* ♀, along the inner margin, as in *P. demophile* ♀ (fig. 3, *l*). Simultaneously with this change the dark border of the hindwing is much broadened (ib., *h*), and in some specimens of *P. demophile* ♀, as in the one figured, the white ground colour is replaced by yellow. These changes are sufficient strongly to suggest the general aspect of the protected group referred to, and it seems difficult to believe that the appearance of the yellow female of *P. demophile* has not a significance derived from this fact.

2. *The "atthis" line.* But the last-named form, viz., the yellow *P. demophile* ♀, though the final Pierine term in one transitional series, is but an intermediate term in another. This second line of development, starting afresh from *P. demophile* ♀, passes into an unmistakable mimetic relation with the protected group that centres round such forms as *Heliconius atthis* (fig. 8) and *Tithorea pavonii.*

Comparing *P. viardi* ♀ with *P. demophile* ♂, we find that in the former insect a further stage of divergence

* See Trans. Ent. Soc. Lond. 1896, pl. III., fig. 2, *k*.

from the original Pierine form has been reached (1) by a slight modification in shape and proportions of that area of the pale ground colour included between the diagonal bar and the dark inner margin of the forewing, and (2) by the appearance of a submarginal series of pale spots on both fore and hindwing (fig. 5, *n*). Both of these changes mark an approximation towards the characteristic aspect of the protected *Heliconius atthis* group; but the final link in the Pierine chain, viz., the form represented in fig. 7, which appears to be the female of *P. locusta* or of a closely allied species, brings us nearer still. Here the pale area on the apical side of the diagonal bar (*m*) shows a tendency to be broken up into separate spots; and the pale ground colour, which in *P. viardi* ♀ is uniformly yellow, in *P. locusta* ♀ only retains the yellow tint proximally, the subapical area (*m*) and the submarginal spots (*n*) having resumed their original white. These submarginal spots have also diminished in size and become more compact in outline. In all these respects a further approach is made towards *H. atthis*, and the whole series from *P. phaloe* or *P. calydonia* to *P. locusta* ♀ and *H. atthis* affords as striking a succession of transitional forms as that before traced from the same ordinary Pierine types up to *Mylothris pyrrha* ♀ and *Heliconius numata*.*

3. *The "inachia" line.* In this line an early step in advance of the usual Pierine pattern is taken by *Pieris pandosia*.† On the hindwing underside of this species appears a narrow chestnut-coloured streak in the midst of the dark hind-marginal band, running parallel with the hind border of the wing. In *P. leptalina*, Bates (= *P. pisonis*, Hew.), both surfaces of the forewing show a diagonal dark bar as in *P. calydonia* ♀ and other species; there is also a transverse dark bar crossing the undersurface of the hindwing nearly parallel with the costa (fig. 2). In *P. pandosia*, where the distal end only of this

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* Trans. Ent. Soc. Lond. 1896, pp. 65–70. It should be added to the foregoing that *P. viardi* ♀ itself is probably attracted by *H. charitonia*, which may perhaps be considered an outlier of the *H. atthis* combination. This is analogous to the attraction of another intermediate term in the *atthis* line, viz., *P. demophile* ♀, by the *agna* group.

† Figured by Hewitson, Exot. Butt., "Pieris," pl. II., fig. 14, and *ibid.*, pl. VI., fig. 39.

latter bar is indicated, the chestnut-coloured streak takes no part in its formation; in *P. leptalina,* however, the same chestnut-coloured streak is better pronounced along the hind margin than in *P. pandosia,* and is prolonged for a short distance along the transverse bar (fig. 2, *o*). In this way a considerable resemblance is brought about between *P. leptalina* and some of the well-known transparent neotropical Danainæ, which are presumably protected, such as *Napeogenes inachia* (fig. 4). It is worth noting that the bar *o,* which belongs to the hindwing in *P. pandosia* and *P. leptalina,* appears to represent the dark inner margin of the forewing in the model; and the presence upon its distal portion in *P. leptalina* of a slight prolongation of the chestnut marginal streak may perhaps stand for the turning inwards of the corresponding chestnut marginal band in *N. inachia* along the costal border (figs. 2 and 4).

4. *The "numata" line.* This series needs here no more than a mention, as it has been already discussed and illustrated in the paper above referred to.*

5. *The "tarracina" line.* This is an offshoot of the last, or *numata* line, diverging in the neighbourhood of *Mylothris malenka* ♀, or perhaps somewhat further back towards the original *Pieris.* The remarkable form *M. alethina* ♀ shows a near approach to the pattern of *Tithorea tarracina* and other associated species; its own aspect being probably derived from a type like *M. lorena* ♀ or *M. malenka* ♀, in which the yellow of *P. demophile* ♀ has persisted, and the base of the forewings has become overspread with black.†

General Considerations. There is, therefore, in each one of these cases, a continuous line to be traced; starting in every instance from the same ordinary Pierine form, and passing through a graduated series of closely-allied

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* Vide *supra*, p. 319, note.

† Three at least of the above five lines of development, viz., the *agna*, the *numata*, and the *inachia* lines, can be paralleled from the genus *Dismorphia* and its allies, and it is interesting to see in the latter case how the same ultimate result is brought about by somewhat different means. But I have not attempted to include species of *Dismorphia* within the above series, because the affinity of this genus with *Pieris* and *Mylothris* is not close, and its own course of mimetic development, so far as phylogeny is concerned, must be regarded as completely independent.

species until it terminates in a *Pieris* or *Mylothris* bearing an intimate mimetic relation with some insect of entirely different affinities. It is further to be observed that, in every instance, the species here considered as the model towards which these diverging series tend, does not present an isolated and independent scheme of coloration, but is itself a member of a larger or smaller group of forms, in addition to the Pierine mimic, all of which are endowed with an aspect similar to itself—in other words, that the mimetic associations do not run simply in pairs, but in groups. This latter fact has long been recognised; and the existence of such mimetic groups has been shown by F. Müller, Meldola, and Poulton to possess a further significance than that originally detected by Bates. The elaborate work of Haase* contains an attempt to give a systematic account of the chief cases of mimetic grouping. But in spite of what has already been written by these and other authors, it may be doubted whether the importance of the principle of mimicry among the factors that have determined the facies of the insect fauna in such a region as the neo-

* "Untersuchungen über die Mimicry," Stuttgart, 1893. It may here be mentioned that several of the above-named insects have been noticed by Haase; who, however, has not attempted to trace in any detail the lines of mimetic assimilation that diverge from the common Pierine stock. He speaks, for instance, of *Mylothris lorena* ♀ and *M. malenka* ♀, which undoubtedly belong to the *numata* group, as having arisen from such forms as *P. demophile* ♀, and considers that the transition took place through forms resembling *P. viardi* ♀. But a careful examination will I believe show that, as stated above, neither *P. demophile* ♀ nor *P. viardi* ♀ is in the direct line passing from the unaltered *Pieris* towards *M. pyrrha* and *Heliconius numata*. Both are, in fact, intermediate terms in the series leading up to an entirely distinct assemblage, that typified by *Tithorea pavonii* and *Heliconius atthis* (Haase's "Bonplandi Tracht"); while *P. demophile* shows evidence of attraction by the protected *agna* group, and *P. viardi* by the dominant form *Heliconius charitonia*. Again, the red streak on the underside of the hindwing in the males of *M. lorena*, etc., is attributed by Haase to "inheritance from the female," but its origin is not traced by him to the primitive basal red common to many Pierine genera. (See Trans. Ent. Soc. Lond. 1894, pp.283–289; *ibid.*, 1896, pp. 72, 73.) *Pieris leptalina*, Bates (*P. pisonis*, Hew.) is spoken of by Haase as representing the first partial assimilation to certain *Ithomias*; rightly, so far as the main fact is concerned; but it may also be noticed that earlier stages of the same assimilation exist in *P. kiçaha*, and, as shown above, in *P. pandosia*.

tropical has ever been fully recognised. The mimetic groups here referred to are no doubt mainly of the "Müllerian" kind; that is to say, they are associations between inedible species of various affinities; each association possessing a conspicuous and distinctive pattern of its own, more or less perfectly reproduced by all its members. In the paper already cited and elsewhere* I have given reasons for considering the principle of Müllerian mimicry to be far more widely operative than has generally been supposed; and I have also endeavoured to supply a test by which, even in the absence of information as to the edibility and relative abundance of the members of a mimetic group, a conclusion may sometimes be arrived at as to whether the assemblage is Batesian or Müllerian. As there are grounds for supposing that the arguments just referred to have sometimes been misunderstood, it will be attempted in the following section to re-state, in as simple language as possible, what appears to be the best interpretation of the facts at present known.

Mimetic Attraction. When a species of butterfly has become established in such a region as the neotropical, where life of all kinds is very abundant and competition extremely keen, it may be taken for granted that the species possesses some efficient means of defence, failing which it would be unable to maintain its position. In very many instances, as is well known, the required protection is essentially afforded by the possession of a nauseous flavour, which causes the butterfly in question to be avoided, when recognised, by some at least of its insect-eating enemies. The possibility of easy recognition in such a case constitutes, of course, an important factor in the safety of the species; since there would be no advantage in being inedible, if the fact only became known in each individual case as the result of an experiment fatal to its subject. It is in consequence of this necessity for "advertisement" that, as is also well known, inedible species tend to assume gaudy and conspicuous colours, and to adopt habits calculated to display their warning signals with the utmost publicity. In this manner the members of a distasteful and conspicuous species are enabled to profit by the experience gained at

* Trans. Ent. Soc. Lond. 1894, pp. 297, 298; *ibid.*, 1896, p. 75.

the expense of other individuals of the same species, some of which must necessarily fall victims to their insectivorous enemies during the "education" of the latter as to the kinds of prey to be sought or avoided. Each form that thus succeeds in establishing itself becomes, in proportion to its nauseous character and the ease with which it can be recognised, a centre of attraction for other species, which, by assimilating their own aspect to that of their model, are enabled to share in the immunity from attack enjoyed by the latter. It is now considered probable by many that this power of attraction is exercised by dominant inedible species over edible and inedible forms alike; there is, however, one important difference between the two cases, which I have before endeavoured to point out, but which seems to need a more explicit statement than has yet been given to it.

Let us first take the case of a species which is edible, and therefore liable to extermination by insectivorous animals. The chances of the survival of such a species depend on the excellence of its means of defence; such as superior swiftness, or the power of concealment, whether by resemblance to inanimate objects, or to some other species protected by a disagreeable flavour. The force which impels an edible species to seek protection by the last-named method, viz., by sheltering itself under the reputation of a conspicuous inedible form, is the well-known "Batesian mimicry." With reference to this, which is the most complete kind of mimicry, it is to be observed that the advantage of association is all on the side of the mimic, and is not shared in the least degree by the model. Indeed, the existence of the edible mimicking species is a source of danger to the form mimicked, inasmuch as any experience gained by tasting the former would be used to the detriment of the latter. From these considerations two consequences follow; the first being that such an association can subsist only when the numbers of the mimic are insignificant compared with those of the model, for otherwise the latter's reputation for inedibility would be interfered with, and eventually destroyed. The second consequence is that the attractive force leading to assimilation between the two forms can act only in one direction; *i e.*, the model attracts the mimic, but the mimic can exert no reciprocal influence upon the model. The latter stands secure upon its own

footing, any departure from which might be attended with danger to itself; while the only part played by the former is to shelter itself under as close an approximation to the aspect of the model as circumstances permit.

We may now take the case of a species possessing a nauseous flavour, and requiring some means of advertisement in order to make its inedibility available for purposes of protection. Two courses may be said to lie open for such a species. First, it may seek advertisement by acquiring a conspicuous and easily recognised aspect of its own, distinct from that of any others; or, secondly, it may obtain a share in the notoriety already attaching to some dominant inedible form by assimilating its aspect to that of the latter, instead of striking out a new line for itself. An examination of the lepidopterous fauna of such a region as the neotropical makes it certain that the latter of these methods, viz., the method of "Müllerian mimicry," has been very extensively followed. Its advantages, as compared with the former method, are obvious. In the first place it assists the memory of predaceous foes by keeping at a low figure the number of distinct inedible types to be learned and so avoided, and in the second place it benefits at least two species at the same time instead of one, and both have therefore an interest in keeping it up; for inasmuch as in this case, as distinct from that of Batesian mimicry, the mimic is inedible as well as the model, the results of experimental tasting will be uniformly the same, and will be favourable to the immunity of both species. It follows that (1) there is no such limit as exists in Batesian mimicry to the number either of individuals or species forming a Müllerian group. An assemblage of this latter kind is only strengthened, not weakened, by fresh accessions; all being alike inedible, and so all contributing to the common safety. (2) The benefit of Müllerian association being mutual, there is a distinct reason, which we saw does not exist in the case of Batesian mimicry, for the model to help on the process of assimilation by itself advancing to meet the mimic.

To summarise the foregoing. Every conspicuous and distasteful form is a centre of attraction for other forms, whether edible or inedible; but in the former case (Batesian mimicry) the mimetic attraction is limited in operation, and acts only in one direction, influencing

nothing but the mimic; while in the latter case (Müllerian mimicry) the mimetic attraction is unlimited and mutual, acting reciprocally in both directions and influencing each member of the group.

This doctrine of the mutual attraction between inedible forms, leading not merely to the copying of one by another, but to the departure of each from its original aspect by the adoption of features belonging to the other, is not simply a speculation, nor does it rest only on *a priori* reasoning. There is much evidence that it represents a fact which does actually take place in nature; and in the two papers above referred to* I have brought forward cases which seem inexplicable by any other principle. I may be allowed to add in this place a further instance, which appears to me for several reasons remarkable.

The instance of P. locusta ♂. In Trans. Ent. Soc. Lond. 1896, p. 72, note, I spoke, though somewhat doubtfully, of *P. locusta* ♂ as a mimic. My suspicion that this was the case at that time fell short of actual conviction. Now, however, after a further careful examination of *P. locusta* ♂ from this particular point of view, I have little or no hesitation in pronouncing it to be a member of a mimetic association of an exceptionally interesting kind.

It will be remembered that the males of *Mylothris lorena*, *M. pyrrha*, etc., form a good illustration of the accurate manner in which the appropriate habits are correlated with adaptive colouring—the mimetic pattern in these instances being confined to the underside, and being in all probability useless as a protection except during the resting position; while the habits of these males, as testified to by Wallace,† are such as would probably render a Heliconiine resemblance during flight a source of danger to its possessors rather than of safety. Similarly in *P. locusta* ♂, it is only on the underside that the mimetic pattern appears, and here again there can be

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* See also an abstract in "British Association Reports," 1894, p. 692.

† "Tropical Nature," 1878, p. 205. See also Haase, *op. cit.*, p. 68. It should, however, be stated that neither of these authors assigns any protective value to the underside of the male forms in question.

little doubt that its use has reference only to the resting position.

The aspect suggested is rather that of several forms of *Heliconius* in general than that of any one in particular; the most definite relation, however, is with the group of which *Heliconius cydno* and *H. galanthus* are examples, a group characterised by the presence on both surfaces, but especially beneath, of a good deal of light yellow often paling further to white. When the undersides of *Pieris locusta* and one of these *Heliconii*, say *H. cydno* (which inhabits the same part of the neotropical region), are compared together, both insects being in the resting position, we find not indeed an exact resemblance, but a general similarity which, judging from other instances, we may consider as probably sufficient to suggest the possession of like qualities. In both there occurs on the forewing a certain amount of white ground colour; on one side bounded by a dark tip, and on the other more or less limited by the dark area of the hindwing; which latter is traversed by a bright yellow streak, and beset about the base with red or chestnut patches. The elements of the pattern in both insects are the same, and their general relation to one another much alike, though the pale marginal band on the hindwing that occurs in this species of *Heliconius* is not found in the Pierine. A further point of interest is the manner in which the partial breaking up of the white colour is effected in the *Heliconius* and the *Pieris* respectively. There is, I think, little doubt that the dark marks on the costa of the *hindwing* in *P. locusta* represent in a general way the dark discoidal spot and a portion of the inner dark area of the *forewing* in the *Heliconius*. The bright yellow line of the hindwing will be seen in each case to terminate in relation with a dark patch; but in the first instance (that of the *Pieris*) this belongs to the same wing; and in the second instance (that of the *Heliconius*) it is contributed to by both wings. This seems to exemplify a principle repeatedly met with in mimicry; viz., that exact homology is disregarded, and the whole exposed surface of the insect is taken as it were as a canvas on which the mimetic picture is painted with a free hand. The relation of this particular group of *Heliconius* with the Pierines is remarkable, and deserves more detailed treatment; here

it will be sufficient to point out that there is more reason to suppose that the *Heliconius* has adopted certain features from the *Pieris* (for example, the whiteness of the ground colour, and the disposition, if not the existence, of the basal red marks) than that the converse alone has taken place.

Reciprocal Mimicry and Convergence. This fact of the reciprocal copying of two or more species by each other is perhaps implied, though not distinctly so, in the term "convergence," which has been used by many authors to express the phenomenon of Müllerian mimicry; but I am not aware that any writer who so employs the term has laid stress on the *mutual* character of the changes involved, or has traced in any instance the actual modifications undergone by both species of a Müllerian couple under the influence of the attractive force existing between them. It seems hitherto to have been taken for granted that a dominant form will attract or retain other species within its own sphere of influence, without being itself attracted in return; whereas the fact is, as we have seen, that each member of an inedible association has more or less influence upon all the rest. The respective value of the attraction exercised or suffered by any member of a Müllerian group will depend on its numbers, its nauseous qualities, and its notoriety. The stronger any species is in these respects, the stronger will be its power of attraction, and the weaker in comparison will be any force tending to draw it in the direction of other members of the group. The actual mimetic path taken by any species will be the resultant of the various forces acting upon it. If the form happens to be a dominant one, these external forces will be insignificant in comparison with its own stability; and it will therefore resist change to a large extent, or perhaps altogether. The most complete intermingling of characters given and taken on both sides may be expected when two species meet on equal terms, neither being strong enough to predominate over the other.

While there can be no doubt of the convenience of the term "convergence," and its suitability to express relations of the kind just discussed, there would seem to be no sufficient reason for disallowing in their case the earlier term "mimicry." This latter word may be quite

legitimately employed to designate the adoption of any new features borrowed from another species. In so far as A copies the appearance of B, it may properly be said to "mimic" the latter, whether the object be to suggest the presence of a disagreeable flavour which it does not really possess, or merely to convey the impression that it and its model are alike in all respects. Müllerian assimilation may be quite as deceptive as Batesian, in the sense of leading to confusion between species essentially distinct; and in the case of a "weak" species being associated with a "strong" one, the departure of a form from the typical aspect of its congeners by the development of strictly imitative features may be as well marked in the one kind of mimicry as in the other. But although either of the terms "Müllerian mimicry" or "convergence" would appear to express quite adequately the general idea of the mimetic relation between inedible species, a separate term is wanted to designate the peculiar give-and-take changes which we have seen are theoretically possible to a greater or less extent in every case of Müllerian association, and which in fact do actually occur in several. It is to supply this want of a term that I have proposed the expression "reciprocal mimicry,"* which is meant to convey, besides the general idea of convergence, the special information that in the cases to which the term is applied, the convergence is brought about not by the simple imitation of one form by another, but by the interchange of features between forms, and their consequent simultaneous approach to an intermediate position.

The foregoing remarks will, I think, have made it sufficiently clear, (1) that reciprocal mimicry can only take place in Müllerian associations, not in Batesian; and that it is therefore, as I have elsewhere said "good evidence of the distastefulness of all the forms between which it can be shown to occur;" (2) that although a mimic which is of relatively plentiful occurrence must be Müllerian, it does not follow that a mimic which is scarce must necessarily be Batesian. An inedible mimic may be either rare or common; an edible mimic must be rare. Judging by these principles, we must conclude that the association of *Pieris locusta* ♂ with *Heliconius cydno* is

* Trans. Ent. Soc. Lond. 1894, p. 298.

Müllerian, and an addition is thus supplied to the evidence already existing in favour of the distasteful qualities of this and other Pierine genera.*

Conclusion. If we take a comprehensive survey of the whole butterfly facies of the neotropical region, we cannot fail to be struck with the numerous cases of mimetic assimilation which it presents. It would in fact almost seem that scarcely any conspicuous form is completely isolated. In a region where enemies to insect life are so numerous, and competition for existence is so keen, a butterfly can hardly afford to be conspicuous unless it is also distasteful; nor is the mere individual possession of these qualities in the majority of instances sufficient for safety. Any form that requires to establish a reputation for inedibility, must as it were seek allies; and no sooner does it make a bid for survival as a nauseous species, than it becomes subject to the influence of mimetic attraction, and probably finds itself drawn into the vortex of one of the great Müllerian associations.

It is no doubt true that the process of mimetic assimilation is subject to limitation by the operation of other forces. Thus it may be needful that the resemblance to a model, though close enough to deceive enemies, should not be so close as to interfere with due recognition between the sexes. We know little of the means by which insects recognise each other, but there are at least some grounds for thinking that they are assisted at times by external marks. This may afford one reason for the different ways in which the sexes of the same species occasionally react to mimetic influences; and it may possibly be the meaning of the retention of a portion of the original white ground-colour in the males of certain species of *Dismorphia.* It is also quite conceivable that the aspect of every species is to some extent controlled by its physiological constitution;† and this fact may tend to disturb the perfect operation of the process of mimetic change.

But notwithstanding all limitations, it remains the fact that any inedible form, in the midst of competing

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* *Vide* Trans. Ent. Soc. Lond. 1894, pp. 297, 298; *ibid.*, 1896, pp. 74, 76.

† *Vide* Presidential Address by Prof. Meldola, Proc. Ent. Soc Lond. 1896, pp. lxxx. *et seqq.*

mimetic systems, is liable to be carried off in this or that direction as it comes under their influence. Sometimes, as in the forms that were discussed at the beginning of this paper, we find several species, closely related to one another by affinity, being drawn away in different directions by the attractive power of the Müllerian groups that surround them; and the same assemblage of cases illustrates the fact that a mimetic change from the original form in the direction of one protected group may serve as a stepping-stone for a further departure towards another.* Sometimes again, as in *Mylothris lypera, M. lorena, M. malenka,* and *M. pyrrha,* we see that in the males a compromise is struck between the ordinary Pierine aspect (used for flight), and a mimetic dress like that of the female (used for repose); while in *Pieris locusta* we find the same compromise in the male, with the curious difference that here even the sexes of the same species have been wrested apart into separate mimetic relations.

Finally, the comparison will perhaps not seem too far-fetched, if the several mimetic groups, each with its own type of coloration, are likened to the solar and stellar systems of astronomers. Sometimes, as in the solar system, there is one central body (*i.e.*, species) dominating the whole, and influencing its attendant planets (*i.e.*, mimics) to an extent in comparison with which the force they themselves can exercise is insignificant. At other times, as in the systems of double and multiple stars, there are bodies (*i.e.*, species) more nearly equal in mass and importance, bound together by mutual attraction into a single combination, where each one effectively controls and is controlled by the rest. We may even push the comparison so far as to find an analogy between those irregular wanderers through cosmic space which from time to time get drawn within the limits of some

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* *E.g.*, as was pointed out above, forms like *Pieris pandosia*, *P. leptalina*, etc., show the result of attraction by the *inachia* group upon *Pieris* of the ordinary kind. Similarly the yellow female of *P. demophile* exemplifies the ordinary form attracted in another direction, that of the *agna* combination. Again, the last-named development of *Pieris* has served as a basis for a further attraction, that by *Heliconius charitonia*, as seen in *P. viardi* ♀; and this latter form has given scope for the influence of the *atthis* group as shown by *P. locusta* ♀.

established system, and certain species which seem to hover on the outskirts of mimetic groups, undecided as it were whether to throw in their lot with one association or another.

I am indebted to Professor Poulton, F.R.S., for free access to the Hope Department, and for permission to figure insects from the collection under his charge.

NOTE.

In the course of the discussion which followed the reading of this paper, my friend Professor Poulton expressed the opinion that the term "mimicry" should be restricted entirely to cases of Batesian association, and should not be applied to resemblances between distasteful forms. I am, of course, entirely at one with Professor Poulton as to the essential difference between the false warning which is the leading feature in the one case, and the true warning which characterises the other; and I agree that it would be most desirable to mark the distinction by the use of separate terms. Though the present paper must stand as it was read, I am willing in future to attempt the restriction which he recommends. Perhaps "Müllerian assimilation" and "reciprocal assimilation," though a little cumbrous, may serve instead of the terms used in the text; and it may be hoped that the advantage of greater precision thus gained will outweigh the disadvantage of having to drop such convenient words as "mimic," "mimetic" and "model" when speaking of a Müllerian group.—*June* 2, 1897.

List of Species Mentioned.

Pierinæ.

Pieris phaloe, Godt.
P. calydonia, Boisd.
P. demophile, Linn.
P. viardi, Boisd.
P. locusta, Feld.
P. pandosia, Hew.
P. kiçaha, Reak.
{ *P. leptalina*, Bates.
{ *P. pisonis*, Hew.
Mylothris lypera, Koll.
M. lorena, Hew.
M. malenka, Hew.
M. pyrrha, Fabr.
M. alethina, Butl.

Heliconiinæ.

Heliconius numata, Cram.
H. atthis, Doubl.
H. charitonia, Godt.
H. cydno, Doubl. & Hew.
H. galanthus, Bates.

Danainæ.

Aeria agna, Godm. & Salv.
Tithorea pavonii, Butl.
T. tarracina, Hew.
Napeogenes inachia, Hew.

Explanation of Plate VII.

Fig. 1. *Pieris calydonia* ♀.
,, 2. *P. leptalina*, underside.
,, 3. *P. demophile* ♀.
,, 4. *Napeogenes inachia*.
,, 5. *P. viardi* ♀.
,, 6. *Aeria agna*.
,, 7. *P. locusta* ♀.
,, 8. *Heliconius atthis*.

In all the Figures

k, diagonal dark bar of forewing.
l, dark bar of forewing parallel to inner margin.
m, pale area on apical side of diagonal bar.
n, submarginal pale spots.
o, transverse bar of hindwing.

N.B., *k* and *l* as in Trans. Ent. Soc. Lond. 1896, Plates III.–V.

1

Pieris calydonia ♀

2

Pieris leptalina under side

3

Pieris demophile ♀

4

Napeogenes inachia

5

Pieris viardi ♀

6

Aeria agna

7

Pieris locusta ♀

8

Heliconius atthis

F.A Dixey pinx^t

West, Newman chromo

Mimetic Attraction

[Reprinted from the Proceedings of the Entomological Society of London, 1897, pp. xx.–xxxii., xxxiv.–xlvii.]

PAPER, EXHIBITION, AND DISCUSSION ON MIMICRY. (*May 5th*, 1897.)

Dr. Dixey read a paper on "Mimetic Attraction." He began by pointing out with the aid of diagrams that the process of mimetic assimilation might start from a given point and proceed along several divergent paths. For example, from an ordinary non-mimetic form of neotropical *Pieris*, such as *Pieris phaloe*, not one only but several divergent series of mimetic modifications could be traced; each passing through a graduated series of closely-allied forms until it terminated in a *Pieris* or *Mylothris* bearing a more or less intimate relation with some protected form or forms of entirely different affinities. Such were the series leading through *P. calydonia* to *P. demophile* ♀, a mimic of *Aeria agna;* the series starting from *P. demophile* and passing into forms such as *P. locusta* ♀, which was in mimetic relationship with *Heliconius atthis*; the series represented by *P. pandosia* and *P. leptalina*, which approached *Napeogenes inachia*; the series dealt with in a previous communication (Trans. Ent. Soc. Lond., 1896, pp. 65–79), which led up to forms associated with *Heliconius numata*; and lastly, a series derived from the one last-mentioned, which ended in *Mylothris alethina* ♀, a mimic of *Tithorea tarracina*.

In all these instances, the model towards which the series tended did not present an isolated scheme of colour, but was a member of a larger or smaller group of forms, associated in external features; such as were shown in the series to be exhibited by Mr. Blandford. These mimetic groups were no doubt mainly of the "Müllerian" kind, that is, they were associations between inedible species of various affinities. Reasons were given for attributing great importance to the operation of the Müllerian principle in producing such a facies as that of the neotropical fauna, and for assigning to Batesian mimicry a comparatively subordinate position. Stress was laid on the facts (1) that Batesian mimicry could exist only when the numbers of the mimic were insignificant compared with those of the model, whilst a Müllerian group was strengthened by every fresh accession; and (2) that the

attractive power in Batesian mimicry acted only from the model towards the mimic, whereas in Müllerian association it was mutual, and tended to produce reciprocal changes. For this mutual modification of characters the term "reciprocal mimicry" was suggested. A relation of the latter kind appeared to exist, *e.g.*, between *Pieris locusta* ♂ and *Heliconius cydno*, and it must therefore be concluded that the Pierid was inedible, a conclusion previously reached in the case of other Pieridæ on more than one kind of evidence. A consequence of the keen competition for life in such a region as the neotropical was that scarcely any conspicuous form was completely isolated. If edible, it would generally be a Batesian mimic; if nauseous, it would be drawn into the vortex of one of the great Müllerian groups. The force exerted by these latter was well exemplified by the facts dwelt upon at the beginning of the paper, which showed the steps by which the members of a single genus such as *Pieris*, and sometimes even the sexes of a single species such as *P. locusta* were drawn apart into more or less intimate relationships with separate Müllerian groups.

Mr. Blandford then exhibited and described the series of Neotropical butterflies from the Godman-Salvin collection, which were shown by him on a previous occasion (Proc. Ent. Soc. Lond., 1896, p. xxxviii.); he stated that he used the term "homœochromatism," originally employed in the "Biologia Centrali-Americana," in preference to Dr. Dixey's term "reciprocal mimicry," to denote the phenomenon exhibited by "Müllerian" groups, because it gave a sufficient indication of its nature without assuming any theoretical consideration as to its origin. The series shown were :—

I. Homœochromatism between Paired Species of the same Genus.

Heliconius galanthus	and *H. luce.*	Guatemala.
H. chioneus	and *H. sappho.*	Panama.
H. cydno	and *H. eleuchia.*	Colombia.
H. althea	and *H. primularis.*	Ecuador.

Each pair was closely alike on the upper-side; the undersides were different, there being common types for the right-hand and left-hand members of the pairs respectively. There was also a progressive modification in the patterns of the upper-side in proceeding from North to South.

II. Homœochromatism between Paired Species of different Genera.

Tithorea humboldti and *Heliconius cassandra*. Colombia.
Tithorea candollei and *Heliconius* sp. Antioquia.
(with these associated *Epicalia chromis*, ♀).
Tithorea bonplandi and *Heliconius hecuba*. Colombia.
Tithorea pavonii and *Heliconius atthis* Ecuador.
(with these associated *Pieris locusta*, ♀).

III. Geographical modifications of Homœochromatic Species of the same Genus.

Heliconius thelxiope and *H. vesta*.

a. Parallel varieties of both species in Cayenne, inosculating with *H. melpomene* at one end of the series, and extending to typical *H. thelxiope* and *H. vesta* at the other end; the varieties occurring without reference to geographical distribution.

b. Fixed geographical paired races of both species from British Guiana, Lower Amazons (Para), Upper Amazons (Pebas), Ecuador and Bolivia, and accompained in the first three localities by homœochromatic races of *H. aœde*.

c. Intermediate forms connecting *H. vesta* with *H. phyllis* in Bolivia.

IV. Extensive Homœochromatic (Müllerian) Groups.*

1. North Central-American Type.—Guatemala to Nicaragua.

Lycorea atergatis.	*Heliconius telchinia*.
Melinæa imitata.	*Eueides zorcaon*.
Tithorea sp.	*Eresia philyra*.
Mechanitis doryssus.	*Protogonius cecrops*.
Ceratinia dionæa.	*Dismorphia praxinoe*.
C. fenestella.	*Mylothris malenka*.

* The genera in the left-hand columns of the list, except *Lycorea*, a true Danaid, belong entirely to the Heliconioid Danainæ (Neotropinæ). Of those in the right-hand columns, *Heliconius* and *Eueides* belong to the Heliconiinæ; *Eresia*, *Anæa* and *Protogonius* to the Nymphalinæ; *Archonias*, *Mylothris* and *Dismorphia* to the Pierinæ; and *Ithomeis* to the Erycinidæ.

Intermediate between Groups 1 and 2.

Melinæa scylax.
Mechanitis lycidice.
Napeogenes tolosa.
Ithomia heraldica.
Heliconius clarescens.

2. South Central-American Type.—Costa Rica to Panama.

Thyridia melantho.
Tithorea helicaon.
T. duenna.
T. pinthias.
Mechanitis isthmia.
Ceratinia decumana.
C. callispila.
Napeogenes tolosa.
Dirceuna relata.
Callithomia hezia.
Hyposcada adelphina.
Pteronymia notilla.
Hypoleria libera.
Heliconius zuleika.
H. formosus.
Eueides vulgiformis.
Eresia nigripennis.
E. pœcillina.
Anæa jansoni, ♀.
Ithomeis imitatrix.
Archonias lyceas, ♀.
Dismorphia deione, ♀.
D. sororna, ♀.
Mylothris malenka, ♀.
Papilio zalates.

Colombian modification of 2.

Tithorea hecalesina.
Napeogenes peridia.
Pteronymia picta.
Heliconius hecalesia.
Eresia ithomioides.
Anæa panariste, ♀.

3. East Brazilian Type.

(*a.*) The apical spots on the forewing yellow.

Lycorea halia.
Melinæa ethra.
Tithorea sp.
Mechanitis nesæa.
Napeogenes xanthone.
Ceratinia laphria.
Heliconius dryalus.
Eueides dianasa.
Eresia esora.
Eresia sp.
Dismorphia astyonome.

(*b.*) The apical spots on the forewing white.

Mechanitis lysimnia.
Napeogenes euryanassa.
Ceratinia daeta.
Heliconius narcæa.

4. Guiana Type.

Lycorea ceres.
Melinæa mneme.
Tithorea harmonia.
Mechanitis polymnia.
Ceratinia philidas.
Heliconius numata.
Eresia sp.
Dismorphia amphione.

5. Upper Amazons.

a. Ega Type.

Lycorea cinnamomeana.
Melinæa pardalis.
Tithorea harmonia.
Mechanitis egaensis.
Ceratinia fluonia.
Heliconius pardalinus.
Protogonius castaneus.
Dismorphia egæana.

b. São Paulo Type.

Lycorea cinnamomeana.
Melinæa cydon.
Mechanitis olivencius.
Ceratinia tigrina.
Heliconius isabellinus.

c. Lower Rio Napo Type.

Melinæa sp.
Mechanitis sp.
Callithomia sp.
Ceratinia sp.
Heliconius sp.
Eueides sp.
Eresia sp.

6. Ecuador Type.

Melinæa cydippe.
Mechanitis mothone.
Ceratinia semifulva.
Napeogenes sp.
Heliconius aristiona.
Eueides acacetes.
Acræa acipha.
Eresia ithomiola.
Protogonius semifulvus.
Papilio bacchus.

7. Central Colombian modification of 6.

Melinæa messenina. *Heliconius messene.*
Mechanitis menophilus.
Napeogenes sp.

The greater part of these groups, which also contained a few moths belonging chiefly to the genus *Pericopis*, consisted of species of the Heliconioid Danainæ or, as they had been recently called, Neotropinæ; one or more species of Heliconiidæ were constantly present, and the associated forms of *Heliconius* might conveniently be regarded as representatives of the respective colour-types. A few Nymphalinæ, Pierinæ, Papilioninæ, and in one case an Erycinid, had been drawn into the vortex. The colour-types which they represented were so far diagnostic of the geographical distribution that a strange specimen belonging to one or other of these groups, which were a few only out of many such that could be put together, could be unhesitatingly assigned by its facies to its original habitat in Tropical America.* But whereas certain groups, such as 1, 2, 3, and 4, were of extensive geographical range, others, such as the Ega group, *5a*, with its peculiar suffused brown coloration, or the Rio Napo group, *5c*, were restricted to a comparatively small area. This was intelligible in the Andean region, where every valley had its own special set of forms and where isolation played the same part as in the evolution of insular faunas, but, as Bates had pointed out, it was a very remarkable phenomenon in the Amazon valley, throughout which the physical conditions were very uniform. He did not propose to dispute either of the theories of mimicry which were associated with the names of Bates and Müller, but they rested very largely on hypothesis and were

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* As an example, group 4 is distinguished mainly by having the hindwings almost or quite black behind the transverse black bar usually present. The same character exists in British Guiana examples of *H. thelxiope* and *H. vesta*, not in other respects true components of the group; it is absent in their Amazon representatives, at least as far as Bolivia, where it turns up again in association with very different groups.

in want of further support from observation and experiment, which would afford a large if arduous field of work to the enterprising naturalist; the difficulties of the subject did not appear to him to be fully overcome by these theories, which should not be pushed so far as to lead to the disregard of other factors which might have influenced the genesis of these groups. One difficulty was that of distribution. As before mentioned, the groups of the Upper Amazon valley were often of limited range; but if they were genetically connected and the conditions of their environment were constant, the causes which brought about association under a common type, if prohibiting deviation therefrom under penalty of destruction, should have operated to extend the limits of a group as widely as possible by acting as a check to variation on its outskirts. If it were assumed that one form were so far dominant as to drag its associates with it in any given direction, it must be also recollected that the principle on which these large "Müllerian" associations were supposed to be based was prohibitive to variation of any component species, either as a whole, or in any part of the range of the system. The logical tendency of such a group would be to extend its limits indefinitely and not to give rise to repeated changes of the colour-type.

Another difficulty was presented by the very close resemblance, at times amounting to identity in external characters, between certain pairs in these groups, a resemblance to which Brunner's epithet, "hypertelic" might be applied. Existing theories postulated a selective elimination by insectivorous birds, etc.; but the birds' discrimination of members of a "Müllerian," *i.e.*, protected group must be in relation to its distinctness from the other insects co-existing in the same region. If, as was frequently the case, such a group was immediately recognisable by its broad features as protected and inedible, such further discrimination between its members as would be necessary to bring about the intimate likeness found, *e.g.*, between many species of *Melinæa* and *Heliconius* was not adequately accounted for by Müller's hypothesis.

With regard to "convergence," which had been put forward as a necessary phenomenon in Müllerian mimicry, the

possibility of parallel variation ought not to be excluded. To take the case of *H. thelxiope* and *H. vesta*, the "typical" forms might be assumed, *ex hypothesi*, to be the most ancestral, and to have acquired their common resemblance by convergence; but from these forms were derived, as the series exhibited showed, a number of paired varieties which were progressively modified in relation to their distribution. There was nothing to show that either species had been influenced in its variation by the other, and that it would not have followed the same course if it had been isolated. And it was conceivable that the causes, in most cases unknown, which brought about modifications in the colour and markings of a species in association with its geographical range, might have produced identical results in two species of the same genus, with a common facies, under common conditions.

Prof. Poulton: He congratulated Dr. Dixey on his careful work, and on the deep interest of the results he had obtained. It was a great source of satisfaction to him that this research had been conducted in the Hope Department of the Oxford University Museum.

He then exhibited a further series of neotropical butterflies from the Godman-Salvin collection, illustrating the various members of the group which had been formed round *Methona confusa*, Butl., and *Thyridia psidii*, L.; the best known moths (of the genera *Castnia* and *Hyelosia*) which fell into the group, were supplied by specimens from the Hope collection. This group which, as regards most of its members, had been originally described by H. W. Bates, occupied a very wide geographical area, and was of special interest, not only on account of the number of forms which entered into it, but also because of the perfection of the resemblance.

Further, he exhibited the smaller group which converges around *Ituna lamira*, Latr., and species of *Olyras*, *Thyridia*, etc., the specimens being selected from the Godman-Salvin collection; he also showed several groups characteristic of Honduras, Surinam, Eastern Brazil, etc., the specimens having been recently acquired by the Hope collection for the purpose of illustrating the principles of Warning Colours and Mimicry. Many of these specimens possessed the special interest that

they were captured by one collector nearly at the same time, and in one locality. In fact, in the case of the Honduras insects (presented by Col. Swinhoe), examples of several different species and genera had been sent in one set of papers as a single species. Thus in the case of these groups evidence was actually forthcoming that the separate species do live together intermingled, and are liable to be confused, at any rate by a human collector.

The term "homœochromatism" was criticized on the ground that it was a mistake in science rigidly to exclude theory and interpretation. A theory might be a good guide to discovery, even if it turned out in the end to be imperfect or wrong. And in this case it was contended that the theories of Mimicry and of Warning Colours had by no means been proved to be wrong, but remained as the only hopeful interpretation of the facts.

He also objected to Dr. Dixey's phrase, "reciprocal mimicry," inasmuch as the resemblances alluded to were those of specially defended insects, and not of forms which, being themselves harmless, lived on the reputation of their better defended neighbours, as in mimicry proper. Protective Mimicry had been defined by the speaker as "False Warning or Deceptive Warning Colours" (pseudaposematic), while, according to Dr. Dixey's contention, there was nothing false about the warning colours of the insects described.*

It was contended that the peculiar local groups, such as those of Ega and the Rio Napo do not offer any difficulty to the theory. The ordinary laws of variation continued to operate after the formation of a group, only in this case the

* It has since occurred to me that terms accurately descriptive for those who accept the theories of Mimicry and Warning Colours may be obtained by an extension of the terminology proposed by me in 1890 ("The Colours of Animals," pp. 336 *et seqq.*). In the majority of cases there is reason for the belief that Müllerian groups have been formed by a gradual approximation towards the appearance of some aggressive and abundant species, or towards that of the most prominent general characteristics of several such species belonging to a specially defended section of Lepidoptera, such as the Euplœinæ or Acræinæ. Müllerian groups of this kind—probably by far the commonest—may be said to possess Synaposematic

change which so often occurs in a species with a wide geographical range, ultimately splitting it up into subspecies and true species, would draw the associated forms after it by the operation of the very principles by which the group was originally formed. If this process were sufficiently gradual no principle of Müllerian association need be violated. Or the facts might be reasonably explained in another way: the dominant (a word which here implies only the commonest and best known, in fact, the most widely advertised of the specially defended Lepidoptera of the district) form might have inhabited the region in question, and assumed its peculiar aspect before the formation of the group, and may have then separately "converted" each newcomer as it arrived in the district. The tendency of a group was certainly, as Mr. Blandford maintained, to extend its limits indefinitely—a tendency which had operated with great success in certain cases. But the spread of species always encountered opposing forces which in many cases acted as effective barriers.

With regard to Brunner's "Hypertely," he maintained that one knew far too little of the details of the struggle for existence to justify the conclusion that it was incompetent to produce such effects. What little was known confirmed the belief that very minute differences might serve to turn the scale. The differences between extremely perfect resemblances and those which were less perfect or only very rough, were probably to be explained by the relative age of the association in the former, or the more complete and rapid operation of natural selection on account of a special reliance on this among other modes of defence possessed by the

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(σύν, together; ἀπό, away; σῆμα, sign) colours, pattern, or appearance, the noun being Synaposeme. They may also be said to possess Müllerian Warning Colours or Common Warning Colours. For those extremely interesting but, as I believe, relatively uncommon cases, in which the approach is mutual—a process of "give and take," so well described by Dr. Dixey—the term Diaposematic (διά, used to express *mutual* relation, as in "dialogue," ἀπό, and σῆμα) may be employed, the noun being Diaposeme. These cases may also be spoken of as Reciprocal Warning Colours. Mr. Arthur Sidgwick has kindly helped in the formation of these new terms. —E. B. Poulton, *June 14th*, 1897.

species. One was compelled to believe that every perfect resemblance began as an imperfect resemblance, and then passed through stages in which the likeness was gradually increased; and it was only to be expected that examples of all such stages should exist at the present day among the numberless forms which exhibited mimicry and common warning colours.

Gradual changes in the geographical distribution of the constituent species along the borders of groups would tend from time to time to bring certain of them within the influence of other groups, and so begin a change in another direction. Furthermore, there was no reason for concluding that the detached members of Müllerian groups must become extinct, as in the case of the Batesian or true mimic. In the presence of other dominant members of a group, any tendency towards resemblance might well be of selection value: in their absence it was by no means necessary to assume that a species, which, *ex hypothesi*, was specially protected in some way, must become extinct, although any further advance towards the likeness would be checked, and the ground gained in the past lost after a longer or shorter interval. To enter the area of another group would tend towards a rapid modification of the old appearance.

The suggestion that parallel variation assisted in the formation of these resemblances was strongly opposed by the fact that the superficial characters were alone affected, and that the closeness of resemblance bore no relation to degree of affinity. For instance, the resemblance between a *Melinæa* and a *Heliconius* was frequently much closer than that between the former and a *Mechanitis*, or the latter and an *Eueides*, in the same groups. Although the interesting facts brought forward by Mr. Blandford with regard to *Heliconius thelxiope* and *H. vesta*, etc., would, taken alone, seem to support his suggestion of parallel variation, yet when they were considered as part of the whole phenomena of Müllerian warning colours, as exhibited and as at present known and understood, in the Neotropical Rhopalocera, one was led to believe that one set of principles had been at work, and that natural selection, which, he contended, offered the only hopeful

solution in the vast majority of cases was the true explanation of the others also.

Further strong support for this conclusion and further difficulty in the way of any other interpretation as yet offered was to be found in the similar behaviour of the groups which in other tropical countries represented the Danainæ, Nectropinæ, and Heliconiinæ of S. America. Thus unmistakable indications of Müllerian association were to be found among the Acræinæ of Africa and among the Danainæ and Euplœinæ of the Oriental Region. It was impossible to contend that these representative groups possessed the monopoly of parallel variation, or of change under direct influence of the environment.

The President: In treating of the Müllerian associations of species closely resembling each other—many of which were so well illustrated by the admirably arranged series of Tropical-American Lepidoptera exhibited by Mr. Blandford—there was always, in his opinion, great risk, in the case of species of the same genus or even of nearly allied genera, of mistaking for mimicry the similarity really due to close affinity in blood. It also occurred to him that in these Müllerian companies, where each component species is admittedly protected, some certainly and the rest presumably, by offensive and distasteful secretions, there did not apparently exist the same necessity for exact imitation as was demanded in the case of the Batesian mimicries, when the very existence of the unprotected edible individual and species depended on the closest simulation of the protected inedible form. The opinion had been expressed that in the latter cases mimicry had sometimes been carried to an exactness in minutiæ quite unnecessary; but he thought that no one, who considered the life conditions under which these mimicries had been brought about—the intensity of competition, the overwhelming fertility, the complex inter-relations of organisms, so characteristic of tropical regions, could seriously conclude that these special modes of protection could by any possibility be too perfect. We might rest assured that imitations so complete as many of them are would certainly not exist if they had not become necessary.

In the discussion of these extremely interesting phenomena it was only too evident how great was the need for prolonged and continuous systematic study of the living forms in their natural environment. The collector in tropical regions, however able and enlightened, and however desirous of contributing to the elucidation of these and kindred problems, was too much hampered by the hindrances and interruptions incident to his main occupation to admit of his undertaking such a series of observations as was essential. What was wanted were *Biological Stations* dealing with the terrestrial fauna on the lines of late so successfully followed in marine biological research.

The discussion was then adjourned till June 2.

Discussion on Mimicry, etc.

The discussion on Mimicry and Homœochromatism in Butterflies, adjourned from May 5, was then resumed.

Dr. Dixey: He wished to add his voice to the chorus of approval and thanks which had greeted the very fine exhibit arranged by Mr. Blandford from the collection of Messrs. Godman and Salvin. He thought that his own views were supported by the contents of the drawers shown, and that the series of examples contained therein were, in most instances, Müllerian associations of an extensive character.

He agreed that the term "homœochromatism" had an advantage in merely denoting the facts, without reference to any theory; but he thought that Mr. Blandford ought not to restrict it, if such were his intention, to Müllerian mimicry. It was equally true that Batesian mimics were homœochromatic with the models they represented.

He was not sure whether Mr. Blandford intended his remarks about the intimate resemblance existing between certain species included in these groups to be considered as a criticism of the Müllerian theory. The course taken by any species was a resultant of the various forces acting upon it, and the perfection of a mimetic resemblance would therefore stand in relation to the facility for its acquisition which was allowed by the other forces tending to modify the external appearance.

Professor Poulton had criticised the use of the term "mimicry" in the case of Müllerian resemblances. The speaker agreed that any ambiguity between these phenomena and Batesian mimicry was to be avoided, but it had not occurred to him that his use of the term "reciprocal mimicry" was open to this objection. He had also been charged with saying that Müllerian mimicry was necessarily reciprocal. Possibly he had conveyed this impression; he did not, however, intend to assert that this form of mimicry must always so demonstrably act as to produce reciprocal alterations among species associated under its influence; but merely that it exercised a constant potential force, in some cases becoming actual and capable of demonstration, towards mutual convergence, whereas in Batesian mimicry the mimic was necessarily without any such influence on the model.

He was glad to hear Professor Poulton say that he was becoming convinced by the speaker's arguments that the Pierinæ were a protected group. He should not himself, however, care to assert more than that much evidence pointing to this conclusion existed in respect to many members of the subfamily—for instance, the genera *Delias* and *Mylothris*; while in some cases the evidence for inedibility was considerably strengthened by the presence of reciprocal change.

Canon Fowler: Could anyone explain the existence of the "predominant partner" which was assumed in the explanation given of these groups? He could not imagine why one species should be stable and the others unstable and dependent upon the former for their characters.

Mr. Elwes: The society was much indebted to Messrs. Godman and Salvin for the loan and to Mr. Blandford for the arrangement and exhibition of these valuable specimens. He doubted if there were any other collection in the world from which such an exhibit as that shown could be got together. To his mind the specimens were of infinitely greater scientific value in their present arrangement than they would be if dispersed throughout a collection in their proper systematic positions.

He therefore pleaded that when the question of their being

sent to their ultimate destination, the British Museum, arose, the possibility of their being kept permanently together might be considered, and their retention in the present arrangement stipulated for. The absence of any rare or unique examples from their proper places in the collection would be more than compensated for by the increased interest which would thus be secured, and the series would serve as a model to curators of other museums in the art of making butterfly collections interesting and instructive.

He had to speak that evening without the advantage of having heard the first part of the discussion, and what he had to say was therefore based mainly on the abstract which had been furnished of it. He thought, and his opinion was formed on personal experience gained in collecting in many countries, tropical and otherwise, that there was too much assumption about either the Batesian or Müllerian theories of mimicry. In many supposed cases he doubted whether the so-called models were protected either by taste or smell, and he thought that the importance of birds as enemies of butterflies had been overrated. It seemed to him that the protection supposed to be given to the imago was of little account in the perpetuation of the species when compared with the destruction which took place in the larval or pupal stage by climatic influence, as well as by insect and other enemies.

However beautiful these explanations of the phenomena of mimicry were in theory they ought not in most cases to be treated as proved scientific axioms. He did not deny that there might be some truth in each of the theories which had been put forward, but it appeared to him that altogether too much stress was laid on them. Had any observations been made which would justify the statement that the members of a Müllerian group were inedible, as was asserted by Dr. Dixey in his quoted remarks?

He desired to call attention again to a passage in his Presidential Address on Geographical Distribution (Trans. Ent. Soc. Lond., 1894, pp. lxv., lxvi.). He had said: "What is most remarkable is the existence, at high elevations in various parts of the Andes, and at sea level in South

Chili and Patagonia, of several genera and species elsewhere unknown in the Neotropical region, and which are isolated from their congeners in North America by an enormous area of country.

"Among these *Trifurcula huanaco* is a remarkable species which occurs in the Andes of Bolivia, at 16,000 to 17,000 feet, and has a marvellous likeness to *Baltia shawi*, found at a similar elevation in Ladak.

"*Phulia*, a genus of three or four nearly allied species also occurring at great elevations in the Andes and Chili, has a striking resemblance to *Synchloe butleri*, a species which accompanies *Baltia* in Ladak. If similar conditions of environment do not produce similar effects, how can these extraordinary cases of resemblance in remote and disconnected areas be accounted for?"

He hoped that entomologists who resided in places where any of the supposed instances of protective mimicry occurred would pay special attention to the life-history of the species affected by it, as such observation alone could prove or disprove the question.

Mr. Verrall: Homœochromatism was not a phenomenon confined to the tropics. Homœochromatic resemblances existed even in Europe between Diptera and Hymenoptera, and it must be assumed that they stood in relation to the protective armature of the Hymenoptera.

Col. Swinhoe: A challenge had been held out as to whether the distasteful qualities of protected Lepidoptera had been experimented on. As an example of a species, of which such qualities were placed beyond doubt, he instanced *Danais chrysippus*, one of the most widely-spread protected models. This insect was so free from attack, owing to its nauseous character, that the protection extended even to dried examples. These would be found untouched in a box of insects, although the remainder of its contents had been destroyed by mites or *Anthreni*. He did not doubt that there were many other protected Lepidoptera, including many Pierine genera—for example, all the species of *Teracolus* appeared to be inedible.

Mr. Jacoby: If protected and inedible species were so

widely distributed, why were they not universally imitated by unprotected insects? He did not think that sufficient proof had been given of the existence of protection.

Sir George Hampson, Bart.: In his personal experience in S. India he had found that it was quite an exceptional thing to see birds catch, or even attempt to catch, butterflies, whilst it was a matter of daily occurrence to see them taking other insects, especially moths, etc., started from a position of rest. In the cases he had witnessed the *Euplœæ* and Danaidae were caught as often as any others, but usually escaped eventually from the beak of the bird and flew away none the worse owing to the toughness of the integuments.

The only bird he had observed frequently to pursue butterflies was the common Indian Bee-eater, which he had seen hawking Pieridæ, and among them *Teracolus*, which Col. Swinhoe had expressly referred to as a protected genus.

He thought the cause demanded by these theories was inadequate to produce the results assigned to it.

The Hon. Walter Rothschild: It had struck him that it was much more conceivable that certain climatic influences, etc., had played a part in bringing about these resemblances, and he thought that these groups assumed the same appearance because one given influence was at work on them. Such a case as that of *Papilio merope*, and its various representative forms inhabiting Africa (except the Palæarctic North part) and Madagascar were inexplicable by mimicry alone. This *Papilio* was monomorphic in Madagascar, the female being similar to the male both in colour and form of wings, while the representative found in Abyssinia had the hindwing tailed like the male, but possessed a decidedly "mimetic" pattern. In this respect it resembled the female forms of S. and W. Africa, which were, however, tailless. He contended that these geographical forms of *Papilio merope* had probably sprung up under the direct influence of the external conditions of the respective areas rather than in consequence of the direct selection of specimens with a more "mimetic" pattern.

Canon Fowler: There was too much assumption about the current theories.

Mr. McLachlan: A point that appeared to him to be a good deal overlooked in this matter was the possibility that two species might go on independently and yet apparently mimic each other by arriving at the same results in their modifications.

Prof. Weldon, F.R.S.: He did not intend to enter upon the details of mimetic resemblances or upon the theories which had been put forward, but, speaking as a visitor, he would like to take the opportunity, as he did whenever an occasion presented itself, of pointing out to entomologists that the truth or falsity of these theories was capable of being tested to a large extent experimentally, and especially by experiments which would give a basis for statistical determinations.

Thus, if one took a mimetic species distributed over a large area, homœochromatic with one species in one district, and with another in another district, such a species on theoretical grounds must be variable and susceptible to a moderately rapid selective action.

In any given area, although the examples caught might conform fairly closely with a common type, the species must still be variable and capable of selection; if the theories were true there should be evidence of continued selective destruction, and this could be ascertained by experimental breeding on a large scale from eggs of wild individuals. A comparison of the examples thus reared with an equal number of wild specimens from the same locality would show whether there was any greater variability among the bred forms. Assuming that sources of error had been excluded, such a result would be good evidence of the existence of continued selection tending to ensure conformity with the model.

Mr. J. J. Walker: He was unable to believe that birds were effective agents in causing mimetic resemblances. During all his experience as a collector in different parts of the world he had never seen a bird pursue and catch a butterfly but once. On the other hand, butterflies were often eaten when at rest by lizards, small mammals and monkeys.

Col. Yerbury: During his personal experience of many years in India and Ceylon he had hardly ever seen a bird

touch a butterfly. Some years ago the question was raised by the Bombay Natural History Society, and he, with others, took notes on the subject. He recorded two cases only during three years' observing. It was significant that while the flocks of locusts and white ants were attended by vertebrates of all orders, the flocks of butterflies in Ceylon (locally known as "snowstorms") were attended by one species only of bird, and that but seldom.

In his opinion the enemies of butterflies were chiefly, if not entirely invertebrate. In Ceylon two protected species, *Euplœa core* and *Delias eucharis*, were largely taken by a mantis, *Gongylus gongyloides*, while two of the large Asilidæ, *Promachus maculatus* and *Scleropogon ambryon* preyed largely on *Danais limnace*.

Mr. Blandford: In criticizing the term "homœochromatism" Prof. Poulton had, he thought, somewhat mistaken the speaker's attitude. He had no intention whatever of excluding theoretical considerations, even if he could not accept them at their full value. But it was obviously unjust that a class of facts, about which there could be no dispute, should be labelled with a collective name implying the acceptance of a theory which, however well it might stand criticism, had certainly not yet been established. He preferred to keep one terminology for the facts and another for the explanatory theory.

The wideness of meaning which he proposed to attach to the term "homœochromatism" required some explanation. Certainly he conceded that it covered cases of Batesian mimicry; but if generally adopted, it would probably prove convenient to give it a more restricted and conventional meaning by their exclusion: such a conventional limit had constantly to be applied in terminology. In order to keep the nomenclature of these facts independent of speculation it seemed desirable to employ the words "mimic" and "model" without reference to the questions of Batesian or Müllerian mimicry, the essential character of a "mimic" being that of a wide departure from the general type of its genus or subfamily with a resulting likeness to a model which was not, or scarcely, modified thereby; in homœochromatism, as he

desired to limit the term, and as he had illustrated it, no such one-sided departure was manifest.*

The President had called attention to the risk, in the case of species of the same genus, or of nearly allied genera, of mistaking for homœochromatism a similarity due to blood-relationship. Of course, the value of resemblances had to be estimated in relation both to the range of form existing in the genera or sections of a genus involved, and to distribution; and the speaker did not admit that such a mistake had been made in respect to any single species of his exhibit. As far as his knowledge went, instances of non-mimetic homœochromatism among Neotropical butterflies were entirely confined to the Neotropinæ, Heliconiinæ, and Hesperiidæ, although other subfamilies afforded mimetic forms.

He had brought forward certain difficulties attending the current theories; Prof. Poulton's epicriticism thereon was based largely on the assumption that each group possessed some dominant form. The speaker had already pointed out that the Müllerian theory was opposed to the existence of dominant forms, and he knew of no direct evidence that such actually were present—that was, species which could so far influence a group as to compel its components to change when they changed. His objections as to geographical distribution had been met by two counter-suggestions, one of which presupposed that a series of dominant forms had preoccupied the country and had influenced the appearance of the protected species which subsequently invaded it; but one could not bring oneself to believe without strong evidence that the groups of insects concerned, the Heliconiinæ and Neotropinæ, were not coeval in distribution. Prof. Poulton's comments on "hypertely" again presupposed the

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* Homœochromatic pairs, such as those of Series I. in my exhibit, are not demonstrably in the relation of "model" and "mimic," but in one for which some other word must be found. I would suggest that each member of such a pair, or group, which does not show the departure indicative of a mimetic form, be called the "homotype" of its associates. Thus *Heliconius galanthus* would be the homotype of, or homotypic with, *H. luce.*—W. F. H. Blandford, *July*, 1897.

existence of a dominant form in each group, the other components of which were capable of being arranged in a descending order of resemblance to it. That was scarcely borne out by the specimens. A group such as that shown from Panama presented several hypertelic pairs and did not support the idea that the species could be arranged in degrees of adaptation towards one particular model. Whilst the facts of geographical distribution afforded, in his view, a real objection to the Müllerian theory, he did not look to distribution alone as likely to have had a considerable share in the production of these groups.* It might have had some; but their production might conceivably be due to a variety of causes, and not one alone.

He had certainly intended his remarks on hypertely to be taken as a criticism of the Müllerian hypothesis.

However effective a destructive agency might be in producing change, directly it became non-selective, the resulting change must stop short at the point reached; and his argument was that the process of discrimination by birds, the only available agents, would be limited to the recognition of a group of associated forms as an inedible whole, and being superfluous if carried farther would not be exercised so as to bring about such minute resemblances as were often met with. As an instance, he might mention the two Brazilian groups, differing in the white or yellow colour of the apical spots of the forewing. To use a rough illustration, a person whose object was to avoid the society of a policeman would betake himself off at the first sight of the familiar uniform and would not stop to decipher such minutiæ as the distinguishing number thereon. His view was strengthened by the President's admission that in Müllerian groups there apparently did not exist the same necessity for exact imitation as was demanded in the case of Batesian mimics; it practically conceded his point.

Every one who had listened to the discussion must, he thought, be struck with the amount of doubt thrown on the

* The objections to any explanation based on distribution alone have been forcibly stated by Fritz Müller himself. "Kosmos," 1882, p. 262.

bird-theory by speakers whose competence and opportunities for observation were quite beyond dispute. Further important evidence on this point had been lately given by M. Piepers (Congr. Internat. Zool., III., p. 460) who had studied the question in Sumatra and Java for twenty-eight years. In that time M. Piepers had seen four cases only of butterflies, two belonging to the "protected" genus *Euplœa*, being attacked by birds; and his paper referred to the fact that neither Pryer, after twenty years' observation in Borneo, Skertchley nor Scudder had seen or accepted such a phenomenon. M. Piepers had arrived at the sufficiently striking result that mimicry had nothing to do with Natural selection.

The premisses necessary to support either theory of Mimicry had been unduly neglected. For example, though evidence existed to show that the models were protected and inedible, the proof of the edibility of mimetic butterflies had not received enough attention; it was necessary to Bates's theory, and all the more so since Dr. Dixey's work on the "Müllerian" character of certain Pierinæ. These theories, indeed, were really working hypotheses, the object of which was to suggest experimental work tending to prove or disprove them; they were not yet to be put forward dogmatically as true and as convincing proofs of Natural selection. To insist that these homœochromatic groups owed their origin merely to the educational requirements of birds had led, in his view, not so much to a development as to a stifling of broad speculation on and inquiry into the problem.

The facts presented by the *Ithomiæ* (s. lat.) had scarcely been touched upon in the discussion. Almost every colour-type among these insects, however insignificant in appearance, was represented by species of two or more of the genera into which the old genus *Ithomia* had been divided; so that the *Ithomiæ* might be said habitually to exist as homœochromatic pairs. The coloration of many of these pairs, consisting of nothing but a few black patches and a white or yellow patch on a transparent ground was far from exhibiting the striking features which one was led to believe were characteristic of warning colours.

Personally, he was not disposed to reject Bates's theory which, even if of less general application than was commonly supposed, was strongly supported by evidence from other orders of insects, but he was unable to accept that which had been called by the name of Fritz Müller. What was to take the place of the latter? At present, nothing. Until more information had been collected on the habits and variation of homœochromatic species, and on selective agencies, there were no data on which a new theory could be legitimately founded. But he desired to call attention to a significant passage in Bates's original paper on Mimicry (Trans. Linn. Soc., 1861, p. 501). Bates said therein: "The process of the creation of a new species I believe to be accelerated in the *Ithomiæ* and allied genera by the strong tendency of these insects, when pairing, to select none but their exact counterparts; this also enables a number of very closely allied ones to exist together, or the representative forms to live side by side on the confines of their areas, without amalgamating." Such a statement indicated the possibility that sexual selection, or the segregation of forms might take place as a direct act of perception on the part of the insects themselves. If such a phenomenon were shown really to exist, it would remove many of the difficulties which the present theories entailed, and in view of Bates's definite and repeated statements, some proof or disproof of them should be attempted before the Müllerian theory came to be regarded as more than a merely provisional suggestion.

The President: The point had been raised by Mr. Elwes that the destruction of species in the imago stage was of little importance when compared with the much greater destruction of larvæ and pupæ which took place. As a matter of fact, he could bear witness that certain species at any rate of *Danais* and *Acræa* were distasteful and protected in all stages. The larvæ and pupæ of *Danais chrysippus* and of five or six species of South-African *Acræa* were rejected by cage-birds and common fowls; they were highly conspicuous (especially the pupæ of *Acræa*, which are white or yellowish-white with orange and black bars and spots, and suspended indiscriminately on green leaves, dark-brown bark of trees, tarred

palings, etc.) and all gave out an odour weaker than, but of the same character as, that emitted by the perfect insects.

With respect to the term "homœochromatism," it had this disadvantage, that it was at once too wide and too restricted—too wide, because it did not exclude cases of resemblance due to mere relationship, and too restricted, because it left out of sight the similarity in shape of wings or body, or of movement and habit which often made up part of a mimetic likeness.

He did not agree with Mr. Rothschild as to the case of *Papilio merope*, considering that cases in which the ♀ alone was exactly modified in imitation of a protected form (or, as in the instance under notice, of three or four differing protected forms) were, by reason of the extraordinary contrast with the unmodified ♂, more striking and unmistakable instances of obvious and indisputable mimicry than even those in which both sexes were similarly modified. As regards the Abyssinian representative of *P. merope* named *P. antinorii*, which until recently was thought like the Madagascar and Comoro representatives (*P. meriones* and *P. humbloti*) to have the sexes alike, without any mimetic modification of the ♀, Prof. Kheil had described and figured in 1890 two forms of the ♀ (collected, with seven ♂♂ and two ♀♀ coloured like the ♂, at Lake Tana by the late Dr. A. Stecker) respectively closely imitative of *D. chrysippus* and *Amauris niavius*, but still retaining the conspicuous tails on the hindwings which all the other known forms of ♀ of the allied species on the African continent have lost. There, it seemed to him, was a most interesting and conclusive case of *mimetic modification still actually in progress*, the ♀ usually resembling the ♂ in both colouring and pattern as well as in outline of wings, but also presenting two other forms, each profoundly modified in simulation of a protected Danaine butterfly, yet an incomplete mimicker in so far that the tailed outline of the hindwings remained unaltered.

He must admit that the capture by birds of butterflies was rare, but he had himself seen birds, especially the Drongo shrike, chasing butterflies.

Mr. Mansel Weale had recorded his having witnessed the capture of the ♂ *Papilio cenea* (the S. African representative of *P. merope*) by the Fly-catcher, *Tchitrea cristata*; and Mr. T. Ayres has observed that the small King-hunter, *Ispidina natalensis*, fed almost entirely on butterflies.

The larger Madagascar Chameleons also ate butterflies, but appeared to show no discrimination. Lizards attacked them, but must necessarily see the undersides only, which were protectively coloured in many cases.

As regarded the known protected butterflies, it should be borne in mind that there was very little difference in colouring and pattern between the two surfaces of the wings in the *Danainæ* and *Acræinæ*, so that warning indications of distastefulness were shown almost as conspicuously when at rest as when in flight. The importance of this as a means of protection was manifest, and was further evidenced by the fact that it was exhibited very markedly by the mimicking forms as well.

The chief invertebrate enemies he had noticed were Asilidæ and dragon-flies.

It seemed to him impossible to explain except by the theory of mimicry such cases as that of *Danais chrysippus*, a widely distributed and very common insect which was attended by a troop of mimetic species wherever it went.

Dr. Dixey: It was too late to deal fully with all the points which had been raised, and he must necessarily leave some unanswered for that reason, and not because he undervalued their importance.

He agreed with Canon Fowler as to the danger of making too much assumption upon a matter such as mimicry—it was a subject upon which he had no desire to dogmatise. His position was rather this:—Supposing the theory that such and such forms were inedible seemed to supply a provisional explanation of observed facts, it was desirable to work out fully the logical consequences of such a theory, and then to make a fresh appeal to observers for verification.

Mr. Elwes had laid stress on the importance of getting more observations from naturalists resident in the country

where these phenomena existed; with that the speaker fully agreed.

With respect to Mr. Elwes's question as to the reason for concluding that the various members of a "Müllerian" group were inedible; that was an inference which was drawn from several data, in some instances resting on direct observation, in others depending mainly on the accordance of the characters exhibited with the logical requirements of the theory. Cases of the latter kind awaited verification.

The suggestion made by Mr. Rothschild with regard to the similar results produced by a similar environment did not remove the difficulty; for these effects were not uniform, and even closely allied species inhabiting the same region might differ widely in aspect.

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MIMICRY IN BUTTERFLIES OF THE GENUS HYPOLIMNAS AND ITS BEARING ON OLDER AND MORE RECENT THEORIES OF MIMICRY. By Prof. EDWARD B. POULTON, M.A., F.R.S., University of Oxford, England.

THE theory of mimicry suggested by H. W. Bates in 1862 explained the superficial resemblance of a rare to a common species in the same locality by supposing that the latter possessed some special means of defence (such as unpleasant taste, smell, etc.), and that the former, without the special defence, was mistaken by enemies for the latter, and thus escaped a considerable amount of persecution. The relation may be compared to that existing between a successful well-known firm and another small unscrupulous one which lives upon its reputation. On the other hand, Bates thoroughly recognized the existence of resemblance between the specially defended forms themselves. These he could not explain by his theory of mimicry, and suggested that they were a result of the influence of locality. Many years later Fritz Müller satisfactorily explained this difficulty by suggesting that a common type of appearance simplified the education of enemies and thus was the means of saving life. The lives of many individuals must be sacrificed before enemies have learned to recognize and to avoid the colors and patterns which indicate some special means of defence, and the fewer such patterns in any locality the smaller the sacrifice. The relation may be compared to that between two successful firms which combine to use a common advertisement.

This latter theory, although received rather coldly at first, has gradually made way, and seems now likely to occupy a good deal of the ground

formerly believed to be covered by the former theory. Thus, Dr. F. A. Dixey, of Oxford, has recently shown that South American *Heliconinæ* are affected by the color of certain *Pierinæ* which have hitherto been looked upon as true Batesian mimics of the former.

The old-world nymphaline genus *Hypolimnas* has been regarded as one of the best examples of mimicry, but an unbiassed examination leads to the opinion that it affords a case of Müllerian rather than Batesian resemblance.

In India the female of the common species *H. bolina* resembles *Euplœa core* while the male is a dark butterfly with a large white spot, shot with blue, on each of the four wings. Throughout the Malay Archipelago representative species occur with males like that of *H. bolina* and females resembling the local Euplœas. Occasionally, as in Ke Island and the Solomons, species of the genus occur in which the male as well as the female resembles a *Euplœa*. In Fiji the male is as in the Indian species while the female is extremely variable, ranging from forms like the male through intermediate varieties, to be brown and straw-colored individuals. The Euplœas of Fiji are not sufficiently known, but it is very improbable that all the forms of the female *Hypolimnas* are mimetic. A still more instructive case is that of the *nerina* form of female found, with a male like that of *H. bolina*, in Australia, Celebes, New Guinea, and other E. Indian Islands and in many of the Polynesian groups.

This conspicuous and abundant butterfly has, in addition to the four white-and-blue spots of the male, a large reddish brown patch upon each fore-wing. This well-marked form resembles no other butterfly except the *Danais chianippe* of Celebes, and, as this latter appears to be very rare, it is far more probable that the resemblance has come from the other side, and that the *Danais* has approached the *Hypolimnas*.

In Africa the sub-genus *Euralia* is represented by several species which resemble in both sexes species of the Ethiopian Danaine genus *Amauris*.

Finally there is the well-known and widespread *Hypolimnas missippus* which accompanies *Limnas chrysippus* throughout its range; while the female of the former resembles the latter very closely. In this case it is certain that we have to do with no struggling hard-pressed form, for the *Hypolimnas* has recently established itself in some of the West Indian Islands and in Demerara — localities in which its model, *L. chrysippus*, is as yet unknown.

To sum up — the genus *Hypolimnas* is distinguished among nymphaline genera for the extent to which its numerous and widespread species resemble the local distasteful forms of Euplœinæ or Danainæ.

Upon the older theory of Bates this would be explained by supposing that the genus is very hard-pressed in the struggle and has thus been driven to mimicry almost everywhere. Upon the newer Müllerian theory it is supposed that the genus is distinguished among nymphaline genera by some special defence. probably in the way of taste or smell or indigestibility, and that it has been to its advantage to adopt the advertise-

ment of still better-known and probably still more distasteful forms in its locality.

The abundance of the various species, the conspicuous *nerina* form of female, and the resemblance of a rare Danaid to it, the recent spread of *H. misippus* beyond the limits of its model all support this latter interpretation.

MIMICRY AS EVIDENCE FOR THE ANCESTRAL HOME OF A WIDE-RANGING SPECIES. By Prof. EDWARD B. POULTON, M.A., F.R.S., University of Oxford, England.

WE know on historic evidence that *Anosia plexippus* has spread and is spreading through the warmer parts of the world. If we had not this evidence, it might still be inferred with safety that North America is the ancestral home as compared with the other countries now inhabited by this species. In North America we find a very perfect mimic in *Limenitis misippus*, while in no other country has the occupation been long enough to permit of such a resemblance growing up.

Similar evidence indicates that Africa is the ancestral home of *Limnas chrysippus* which now ranges through almost all the warmer parts of the Old World. The far greater effect which has been produced by this species upon the Lepidopterous fauna of Africa as compared with that of other lands, proves a far longer sojourn in the former.

A METHOD OF LABELLING TYPE SPECIMENS IN COLLECTIONS OF INSECTS. By Prof. EDWARD B. POULTON, M.A., F.R.S., University of Oxford, England.

THE method adopted in the Hope Department of the University Museum, Oxford, consists in printing a form of type label to which the reference to the author's description of the species can be added. Such a label is placed on the pin, below the specimen, while a duplicate label is pinned beside it, in the most convenient position for the student. All essential facts are recorded on this label and a second one stating the locality, date of capture, name of captor, and date of presentation. This latter (which is prepared for *all* specimens recently added to the collections) is similarly placed beside as well as on the insect. Ordinary printers' ink is used for both labels because of its permanence; but the type labels are distinguished by a red line just within the margin.

Theories of Mimicry, as illustrated by African Butterflies.
By EDWARD B. POULTON, *M.A., F.R.S., Hope Professor of Zoology, Oxford.*

(An abstract of the paper read before Section D of the BRITISH ASSOCIATION at Toronto on Friday, August 20, 1897. Reprinted from the 'Report' of the Meeting, pages 688–91.)

H. W. Bates, in his epoch-making paper ('Trans. Linn. Soc.,' vol. xxiii. 1862), first gave an intelligible theory of mimicry, and accounted for the superficial resemblances which had been known for so long by supposing that the most dominant, well-defended, and conspicuous forms in a country become the models towards which natural selection leads many of the weaker hard-pressed species in the same locality. The material on which Bates' theory was formed was confined to tropical America, and his generalisation remained incomplete until it could be applied to the other great tropical regions. This want, however, was soon supplied by A. R. Wallace for the East ('Trans. Linn. Soc.,' vol. xxv. 1866), and by Roland Trimen for Africa ('Trans. Linn. Soc.,' vol. xxvi. 1870).

In Bates' original paper a certain class of facts—frequently mentioned and abundantly illustrated—cannot be explained under his theory of mimicry. This is the strong resemblance which is apt to exist between the dominant forms themselves, and which is as minute and as remarkable as the resemblance of the weaker for the stronger species. Bates pointed out that this was unsolved by his theory, and both he and Wallace were compelled to suggest the direct action of some unknown local influence as the possible cause. There the matter rested until Fritz Müller, in a paper published in Kosmos for May 1879, suggested an explanation, viz., that the dominant forms gain an advantage by this resemblance, inasmuch as it facilitates the education of their enemies by giving them fewer patterns to learn. The necessary waste of life by which the education of young birds, &c., is brought about is here divided between the various species of a closely convergent group, instead of being contributed by each member independently. The chief sub-families of butterflies which in tropical America appear to be specially distasteful to insect-eating animals, and which are specially mimicked by others, are the *Danainæ*, *Ithomiinæ*, *Heliconinæ*, and *Acræinæ*. Of these the second and third are confined to this part of the world. The resemblances which Fritz Müller explained are those which occur very commonly between the *Danainæ*, *Ithomiinæ*, *Heliconinæ*, and less commonly the *Acræinæ* of any locality. In order to complete this theory it was necessary to test its application in other parts of the world.

In the East the butterflies which take the place of the four above-named sub-families belong almost exclusively to the *Danainæ*, the *Acræinæ* being represented by very few species. The *Danainæ* are, however, extremely rich in species, and F. Moore first pointed out in 'Proc. Zool. Soc.,' 1883, p. 201, that there is the same relationship between the species of this dominant group that obtains between those of tropical America. Not only do *Danainæ* of very different genera closely resemble each other, but there is often a strong likeness between the species belonging to the two chief divisions of the sub-family—the *Danaina* and *Euplœina*. As in America, these resemblances are always between the species of the same locality.

While, however, Müller's theory received full confirmation from the facts observed in India and the tropical East generally, no attempt has been made until now to apply it to the African lepidopterous fauna. I have therefore examined this fauna from the Müllerian standpoint, and find that in it too the same relationship can be traced.

The dominant distasteful groups of Africa are the *Acræinæ*, which have their metropolis here, and the *Danainæ*. The latter are chiefly represented by the species of the peculiar African genus *Amauris*, and by the abundant and wide-spread *Danais* (*Limnas*) *chrysippus*. I first looked for evidence of convergence between the *Acræinæ* and *Limnas chrysippus*, and soon found what appeared to

be evident traces of it. Such species as *Planema esebria* (certain forms of), *Acræa petræa* (female), *A. oppidia*, and, above all, *A. encedon* (*lycia*) bear a considerable resemblance to *L. chrysippus*, inasmuch as all of them possess a dark tip to the fore wing crossed by a white bar, as in the Danaine butterfly. Looking at the near allies of these species and at the *Acræinæ* as a whole, we may feel confident that this black-and-white tip is not an ancestral character of the group, but a comparatively recent modification. Again, the fact that this character is sometimes more strongly developed in, and sometimes confined to, the female sex agrees with the corresponding relationships in other parts of the world, and furthermore supports the conclusion as to the recent acquisition of the markings.

Convergence between the *Acræinæ* and *Danainæ* of the genus *Amauris* was next looked for and many examples found. Thus *Acræa johnstoni* of East Central Africa certainly suggests the appearance of one of the *echeria* group, such as *A. hanningtonii*, found in the same locality; while in West Africa *Acræa lycoa* resembles the black-and-white *Amauris damocles* and *A. egialea*. Similar resemblances in the West are to be seen between the large black-and-white females of the numerous species of the Acræine genus *Planema* and other Acræas in the same locality, such as *A. carmentis* (female) and *A. jodutta* (female), while the species referred to, of both Acræine genera, bear some considerable resemblance to an abundant West African black-and-white Danaine—*Amauris niavius*. Similar relationships occur in the South-East, where Acræas, such as *Planema esebria* (white form of female) and *P. aganice* bear considerable resemblance to the abundant black-and-white Danaines—*Amauris ochlea* and *A. dominicanus*.

It was of great interest to prove that the members of these convergent groups occur, not only in the same place, but at the same time. Mr. Guy A. K. Marshall has kindly done this work, sending me several groups captured at one place in a single day. At Malvern, near Durban, Natal, on March 6, and again on March 30, 1897, he captured *Limnas chrysippus* and several species of *Acræa*, with the black-and-white tip to the wing. On March 27 he captured, in the same locality, the black-and-white Planemas (*Acræinæ*) *P. esebria* and *P. aganice*, together with an abundant black-and-white *Neptis* (*N. agatha*) and a closely similar day-flying moth, *Nyctimeris apicalis*. It is very probable that these latter forms do not mimick in the Batesian sense, but are themselves specially defended and fall into a Müllerian group. Mr. Marshall did not, on that day, capture any of the black-and-white *Danaïnæ*. Mr. D. Chaplin, however, on April 5, 1896, obtained at Berea, a suburb of Durban, *Amauris ochlea* and *Planema aganice*, as well as *Limnas chrysippus*, with two species of convergent Acræas (*A. encedon* and *A. petræa*). Mr. F. D. Godman and Mr. O. Salvin have kindly presented these specimens to the Hope Collection at Oxford.

I think it must be admitted that there is now strong evidence for the same convergence between specially protected abundant African species from the same locality as that which is already well known in the tropical East and in tropical America. Various degrees of perfection exist, and it is in every way probable that the resemblance of some members to the standard of their group is not of long standing, and will improve in the future.

Other facts in the colouring of African Lepidoptera also support this interpretation. Thus certain *Lycænidæ* of the genera *Pentila* and *Alæna* are known to fly very slowly, and in the case of the latter to feign death when captured—characteristics of unpalatable forms. While they thus differ in habits from Lycænids generally, they also differ entirely in their appearance, which rather suggests that of an *Acræa*. The same is true of moths belonging to many groups, and perhaps of the abundant butterflies of the genus *Byblia*. Similarly the large group of Lepidoptera, which has for its centre the abundant day-flying moths of the genus *Aletis*, appears to be moulded upon the colouring and pattern of *Limnas chrysippus*, differing only in an even greater conspicuousness, due to the white spots or rings on the black body, and the highly developed black-and-white border to the hind wing. It is probable that the common species of the genus *Euphædra*, which form some of the most conspicuous members of this group, are themselves specially protected. To take one more example, certain species of the Pierine genus *Mylothris*

are rendered specially conspicuous by the interrupted black border to the hind wings, the interruptions extending along the hind margin of the fore wings. A white butterfly with such a border becomes an extremely conspicuous object, and this appearance of *Mylothris* is mimicked, more or less perfectly, by species from a number of Pierine genera, such as *Nepheronia*, *Belenois*, *Callosune*, &c. This is usually explained as an example of true Batesian mimicry, but it is, perhaps, more probable that the *Pierinæ* are very largely a specially protected group, many of the genera of which, so to speak, combine their advertisements, and thus share between them the loss of life which must necessarily ensue during the education of each generation of their enemies.

I think sufficient evidence has been brought forward to show that the theory of mimicry, or rather of common warning (synaposematic) colours, which will always be associated with the name of Fritz Müller, may claim abundant examples in Africa as well as in the other parts of the world in which it has already been proved to hold.

Protective Mimicry as Evidence for the Validity of the Theory of Natural Selection. By EDWARD B. POULTON, *M.A.*, *F.R.S.*, *Hope Professor of Zoology, Oxford.*

(An abstract of the paper read before Section D of the BRITISH ASSOCIATION at Toronto on Monday, August 23, 1897. Reprinted from the 'Report' of the Meeting, pages 692–4.)

Several suggestions have been put forward to account for the superficial resemblances between animals, especially insects, occupying the same geographical area. It has been suggested, and indeed strongly maintained, that food, climate, or some other chemical or physical influence of the locality may have supplied the cause. On the other hand, many naturalists consider that the facts cannot be interpreted by any of these suggested causes, and only receive an intelligible and probable explanation in the theory of natural selection. This theory supposes that the resemblance is advantageous in the struggle for existence, the weaker forms being shielded by their resemblance to the strong and well-defended species (mimicry of H. W. Bates), or the latter gaining by a resemblance which enables their local enemies more easily—and thus with a smaller waste of life—to recognise and avoid them (mimicry of Fritz Müller). The present paper directs attention to certain facts commonly associated with mimetic resemblance which receive a ready explanation upon the theory of natural selection as the efficient cause, but, on the other hand, constitute a serious difficulty in the way of any other theories as yet brought forward.

Natural selection, as is well known, acts upon *any* variations, whatever they may be, which are in the advantageous direction, and are at the same time not injurious in themselves. When the end to be gained (in this case the attainment of a superficial resemblance) is common to a variety of distantly related species possessing entirely different constitutional tendencies, we may feel confident that an approach brought about by natural selection will be by extremely diverse paths of variation. Under natural selection we might predict that such a common end would be reached by great diversity of means, while under the other hypotheses mentioned above a result of the kind is inexplicable. Hence the facts of the case should act as a convenient test between these rival suggestions.

First as to colour. We know but little of the chemical nature of the pigments made use of in mimetic resemblance. One case, however, has been investigated by Gowland Hopkins—viz., the bright tints by which certain S. American *Pierinæ* have come to resemble *Heliconinæ* and *Ithomiinæ* in the same locality. Gowland Hopkins has shown that these close resemblances in colour and pattern are produced by pigments which are characteristic of the *Pierinæ*, and of an entirely different chemical nature from those of their models.

Another very interesting case is that of resemblance to ants. Ants are mimicked more or less closely by a great variety of insects and by spiders. In some cases we find the resemblance brought about by actual alterations in the shape of the body (spiders and many insects), which is modified into a superficial resemblance to the Hymenopteron. In an Acridian—*Myrmecophana fallax*—the shape of an ant is, as it were, painted in black pigment upon the body of the insect, which is elsewhere light in colour and, as it is believed, inconspicuous in the natural environment. In a certain group of Homoptera—the Membracidæ—some of the S. American species closely resemble ants. The Membracidæ are characterised by an enormous growth from the dorsal part of the first thoracic segment (pronotum), which spreads backwards and covers the insect like a shield. In these insects the form of an ant is moulded in the shield beneath which the unmodified body of the insect is concealed. These facts are only explicable by supposing that some great advantage is to be gained by resembling an ant, and

that very different species have attained this end, each by the accumulation of those variations which were rendered possible by its peculiar ancestral history and present constitution—in other words, by the theory of natural selection.

A more elaborate case, which I have recently investigated, is afforded by a large group of tropical American Lepidoptera—moths as well as butterflies—which closely resemble certain common wide-spread species of the Ithomiine genera *Methona* and *Thyridia*. The appearance thus produced consists of a transparent ground with a black border to both wings, the fore wing being also divided by black transverse bars into three transparent areas—the hind wing usually into two. From a comparison with other species of the various families, &c., not altered in this direction, we know that the transparent wings are not ancestral. When we investigate the manner in which transparency has been attained, it is found to be by different methods in the different constituents of the group. Among the numerous genera of Ithomiinæ (*Methona, Thyridia, Dircenna, Eutresis, Ithomia*, &c.) the result has been attained by the reduction of the scales to a very minute size, so that they hardly interfere with the passage of light. This reduction affects the two kinds of scales which alternate with each other in the rows upon the wings of this sub-family, a common result being (*e.g.*, in *Methona* and *Thyridia*) the alteration of the more slender scales into hairs, and of the broader ones into minute bifid structures, still retaining scale-like proportions in spite of their extremely small size. In others, again, the two kinds of scales are reduced respectively to simple and **Y**-shaped hairs, which regularly alternate along the rows. In the *Danainæ* proper, represented by the genus *Ituna*, the transparency is chiefly due to the great diminution in the number of the scales, and those which remain are neither much reduced in size nor altered in shape. In the *Pierinæ*, represented in this group by only a single species, *Dismorphia orise*, the scales are greatly reduced in size, but are neither greatly altered in shape nor diminished in numbers.

Hence in these three sub-families of butterflies transparency is attained in three different ways, viz. (1) by reduction in size and simplification in shape; (2) by reduction in number; and (3) by reduction in size alone.

When we examine the moths which fall into the group, we find a much greater difference in the methods, corresponding to the wider divergence in affinity. In the several species of the genus *Castnia* the scales lose their pigment, although undiminished in size, while they are at the same time set vertically upon the wing, so that light can freely pass between their rows. In the widely separated genus *Hyelosia* the arrangement is nearly the same, except that the vertical scales are much attenuated. In the genus *Anthomyza*, which furnishes the group with many species, the scales retain the normal size, shape, and overlap, but become so completely transparent that the light freely passes through them.

In all the numerous constituents of this large group of Lepidoptera a very close resemblance has been produced by entirely different methods; a result which, it has been argued above, is only consistent with the view that natural selection alone, among all the explanations which have been suggested, has been the cause of the observed phenomena.

I owe to the kindness of Mr. Godman and Mr. Salvin the opportunity of studying all the butterflies of this large transparent-winged group, while Mr. Herbert Druce kindly lent me those moths which are not represented in the Hope Collection in the Oxford University Museum.

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Natural Selection *the Cause of Mimetic Resemblance and Common Warning Colours.*

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NATURAL SELECTION the Cause of Mimetic Resemblance and Common Warning Colours. By EDWARD B. POULTON, M.A., F.R.S., Hope Professor of Zoology in the University of Oxford.

[Read 17th March, 1898.]

(PLATES **40–44.**)

CONTENTS.

(1) *Historical Introduction.*

SUPERFICIAL resemblances between animals, especially numerous in Insecta, were known long before H. W. Bates's paper "Contributions to an Insect Fauna of the Amazon Valley" was read before the Linnean Society on November 21st, 1861, and published in the 'Transactions' the following year (vol. xxiii. p. 495). Some

of the principal records of such observations are to be found in the 'Transactions' of this Society.

W. S. MacLeay, in his 'Horæ Entomologicæ' (London, 1819 and 1821), alluded to certain cases which are now included under Mimicry, viz. the likeness of some Diptera to Hymenoptera (Pt. II. p. 365), and interpreted them, together with many other resemblances of structure and life-history, by the principle of Analogy as distinct from Affinity in Nature. These views were adopted by MacLeay's immediate successors.

The Rev. William Kirby read "A Description of some Insects which appear to exemplify Mr. William S. MacLeay's Doctrine of Affinity and Analogy," before this Society on Dec. 17th, 1822, and the paper was published in the 'Transactions' (vol. xiv. p. 93).

Boisduval, in the 'Spécies Général des Lépidoptères,' published in 1836, remarked (pp. 372, 373) on the resemblance between certain West African butterflies belonging to very different groups.

Prof. Westwood read "Illustrations of the Relationships existing among Natural Objects, usually termed Affinity and Analogy, selected from the Class of Insects," before this Society, on Jan. 17th and May 2nd, 1837, the paper appearing in the 'Transactions' (vol. xviii. p. 409). In the paper many new examples were published and figured, while MacLeay's views were criticised and expanded in an interesting manner.

The same recognition of Mimicry is equally well seen in the names with the termination *-formis* given to so many of our moths, indicating their resemblance to wasps, bees, and other insects. In spite, however, of the knowledge of a large number of instances, the subject made no real progress until the appearance of H. W. Bates's paper. The view then set forth that the resemblances are in themselves beneficial to the possessor was, as far as I am aware, only once suggested before,—in the well-known 'Introduction' by Kirby and Spence. In Vol. II. p. 223 of the second edition (1817) the authors write as follows:—"Some singular larvæ with a radiated anus live in the nests of humble-bees, and are the offspring of a particular genus of flies (*Volucella*, Geoffr., *Pterocera*, Meigen), many of the species of which strikingly resemble those bees in shape, clothing, and colour. Thus has the Author of nature provided that they may enter those nests and deposit their eggs undiscovered. Did these

intruders venture themselves amongst the humble-bees in a less kindred form, their lives would probably pay the forfeit of their presumption." This interesting paragraph, although fully recognizing the utility of mimetic resemblance in species which were then believed to have been separately created and to have come into existence fully formed and complete, sustains a position which is the very antithesis of that taken up by Bates. The contention that the utility of the resemblance has been the cause of its persistence, and, by the selection of variations going further in the same direction, of its improvement, would have been rejected, probably with indignation, by the distinguished authors of the 'Introduction.'

Bates's great paper dealt with the fauna of tropical America, and the generalization was manifestly incomplete until it had been extended to other parts of the world. This confirmation was not long in coming, being supplied for the tropical East by A. R. Wallace's paper published in the 'Transactions' of this Society (1866, vol. xxv.), and for Africa by Roland Trimen's paper, also to be found in our 'Transactions' (1870, vol. xxxi.).

It is remarkable how completely the Linnean Society has been the medium for the publication of classical memoirs upon Mimicry. Up to the year 1870 it contained them all; while in 1858 it served as the channel through which the parent theory of Natural Selection was first given to the scientific world. The next great advance did not take place until 1879, and was published elsewhere.

Bates had called attention to certain resemblances which could not be interpreted under his theory of mimicry, viz. the frequent similarity between the specially defended forms themselves. Forms which are themselves the models for mimicry nevertheless mimic or at least resemble other models. For such cases Bates could only suggest the direct action of some unknown local force or forces, and Wallace followed him in this.

In May 1879 Fritz Müller published a paper in 'Kosmos'* which for the first time offered an explanation, based on the theory of natural selection, of these mysterious resemblances. He suggested that such likeness between dominant forms was advantageous to them, inasmuch as it facilitated the education of their enemies, reducing the amount of destruction which must be wrought during the time in which young birds and other

* "*Ituna* and *Thyridia*: a remarkable case of Mimicry in Butterflies."

animals are learning what to eat with impunity and what to reject. The paper was translated by Prof. R. Meldola and published in this country almost immediately after its appearance (Proc. Ent. Soc. Lond. 1879, p. xx).

The facts which the Müllerian theory sought to explain concerned the fauna of tropical America; the naturalist who explained them was a resident in the same part of the world. A few years later, however, F. Moore (Proc. Zool. Soc. 1883, p. 201) showed that there is the same resemblance between the dominant butterflies of the tropical East; and last year I pointed out that the same facts hold in Africa (Report of the British Association at Toronto, 1897, pp. 688–691). See also Roland Trimen's Presidential Address to the Entomological Society, Jan. 19th, 1898 (Proceedings, 1897, p. lxvi). In the 'Proceedings' of the Entomological Society (1897, p. xxix), as well as in the former paper (p. 691), I argued that such resemblance is not true Mimicry at all, but rather an example of Common Warning Colour, and with the assistance of Mr. Arthur Sidgwick I suggested the term *Synaposematic* as descriptive of it; the term Aposematic having been previously suggested for ordinary Warning Colours (Poulton, Colours of Animals, Internat. Sci. Ser., London, 1890, p. 337).

I have now given a brief account of the leading phases in the history of Mimicry. Even before the appearance of Fritz Müller's paper a great effect had been produced. This immediate stimulus to the investigation of new examples and fresh aspects of Mimicry which followed Bates's memoir, must be ascribed to the fact that then for the first time was offered a good working hypothesis—a hypothesis which seemed to afford an adequate explanation of one class of known facts, which challenged its critics to find insuperable difficulties among facts as yet unknown. In the thirty-six years which have elapsed since the appearance of this great memoir an immense number of facts bearing upon the subject have been discovered, and many naturalists consider that Bates's theory of Mimicry as due to natural selection (supplemented and completed by the kindred theory which we owe to Fritz Müller) has stood the test with complete success and is in a far stronger position than in 1862. This opinion is more generally held among the students of other groups of the animal kingdom than among those who are specially devoted to entomology, but a considerable proportion of the latter also hold it firmly.

In the summer of last year (1897) an excellent opportunity of gauging the opinion of entomologists upon this question was presented by a discussion carried on at two successive meetings of the Entomological Society of London. From the printed report in the 'Proceedings' of the Society, I select the following adverse expressions of opinion as regards the adequacy of natural selection to produce mimetic resemblance, and the statements of any alternative theories or suggestions to account for the facts. The quotations are given in the order in which they are printed.

Mr. W. F. H. Blandford said "it was conceivable that the causes, in most cases unknown, which brought about modifications in the colour and markings of a species in association with its geographical range, might have produced identical results in two species of the same genus, with a common facies, under common conditions." This sentence seems to suggest cautiously the direct influence of climate or some other cause connected with locality. Mr. Blandford, although not disputing the theories of Bates and Fritz Müller, considered that "they rested very largely on hypothesis and were in want of further support from observation and experiment," and that they failed to account for the perfection of the resemblance.

Mr. H. J. Elwes thought "there was too much assumption about either the Batesian or Müllerian theories of mimicry," and he doubted the inedibility of the so-called models, and of the members of the Müllerian groups. Some examples were quoted by him as suggestive of similar effects wrought by similar conditions of environment.

Mr. Jacoby considered that the evidence of special protection was insufficient.

Sir George Hampson "thought the cause demanded by these theories was inadequate to produce the results assigned to it." In S. India he had found it "quite an exceptional thing to see birds catch, or even attempt to catch, butterflies."

The Hon. Walter Rothschild considered "it was much more conceivable that certain climatic influences, &c., had played a part in bringing about these resemblances, and he thought that these groups assumed the same appearance because one given influence was at work on them."

Canon W. W. Fowler thought "there was too much assumption about the current theories."

Mr. McLachlan suggested "the possibility that two species might go on independently and yet apparently mimic each other by arriving at the same results in their modifications."

Mr. J. J. Walker and Col. Yerbury argued that birds are not "effective agents in causing mimetic resemblances."

Mr. Blandford, replying at the close of the debate, maintained that extremely close and exact resemblances are "hypertelic,"—going beyond the limits of the useful, and therefore inexplicable by natural selection. He restated and brought further support in favour of the opinion that birds rarely attack butterflies. He made the final suggestion that possibly "sexual selection, or the segregation of forms might take place as a direct act of perception on the part of the insects themselves"; and quoted the observation of H. W. Bates that the *Ithomiæ* when pairing tend to select none but their exact counterparts (Trans. Linn. Soc. vol. xxxiii. 1862, p. 501).

Only four speakers gave full support to the theories of Bates and Fritz Müller, as explaining the facts more satisfactorily than any other theory hitherto proposed and as likely to receive further confirmation in the future. These four were the President Mr. Roland Trimen, Dr. Dixey, Colonel Swinhoe, and the present writer.

(2) *The various Hypotheses which have been proposed as Substitutes for Natural Selection as the Explanation of Mimicry and Common Warning Colours.*

In the course of the discussion thus briefly epitomized, almost every alternative theory which has been proposed to account for the facts was brought forward.

These theories are as follows:—

(1) The direct effect of some physical or chemical cause or causes connected with locality, such as climate, food, &c. This hypothesis received much support. It may be called the Theory of External Causes.

(2) The independent evolution of a similar appearance in distinct species. This hypothesis was suggested by Mr. McLachlan, and I have heard a similar opinion expressed by Prof. Patrick Geddes. This appears to be the view sustained in G. H. Eimer's just published work 'Orthogenesis der Schmetterlinge' (Leipzig, 1898). I have not yet had the opportunity of studying the essay, but my friend Prof. Weldon has done so

and tells me that it supports a theory of mimicry as due to internal developmental causes, compelling different species to pass through similar phases. The hypothesis that "laws of growth" may cause these resemblances also falls into this category. The suggestion that such laws may account for certain phenomena which are usually explained by the theories of natural and sexual selection was made by Prof. D'Arcy Thompson at the Oxford meeting of the British Association in 1894. This may be called the Theory of Internal Causes.

(3) The operation of Sexual Selection, cautiously suggested as a possibility by Mr. Blandford, who did not, on this occasion, develop the details of the manner in which the principle may be supposed to act. Fritz Müller had suggested this idea in a letter to Darwin, who wrote not unfavourably of it to Prof. Meldola, on Jan. 23rd, 1872. "You will also see in this letter a strange speculation, which I should not dare to publish, about the appreciation of certain colours being developed in those species which frequently behold other forms similarly ornamented. I do not feel at all sure that this view is as incredible as it may at first appear. Similar ideas have passed through my mind when considering the dull colours of all the organisms which inhabit dull-coloured regions, such as Patagonia and the Galapagos Islands" ('Charles Darwin and the Theory of Natural Selection,' Poulton (London, 1896), p. 202.)

In the present paper the attempt will be made to show that many of the known facts of mimetic resemblance do not admit of interpretation by any of the three theories mentioned above, while they do receive a ready explanation on the supposition that the resemblances are useful and have been produced by natural selection. Certain new observations upon the details of the resemblances in a large group of insects, undertaken specially to test these rival theories, will be found to point strongly in the same direction (see Section 12).

In order to render the argument as complete as possible, various considerations which have been urged before will be included as well as those which now appear for the first time.

The objection may be raised that such detailed treatment is unnecessary, and that biologists generally agree in attributing these resemblances to natural selection. To this contention the discussion at the Entomological Society is sufficient answer.

(3) *The Relation of the Resemblances under Discussion to other Resemblances in Organic Nature.*

To those who accept natural selection as the explanation of mimicry, the facts under discussion fall into their place as part of the much wider group of Protective Resemblances in general. Mimicry becomes merely "an exceptional form of protective resemblance" (Wallace, 'Darwinism,' London, 1889, p. 265). The following classification was suggested by the present writer, with the assistance of Mr. Arthur Sidgwick, in 1890 ('The Colours of Animals,' Internat. Sci. Ser., London, 1890, p. 338):—

<table>
<tr><td colspan="2">I. Apatetic colours.—Colours resembling some part of the environment or the appearance of another species.</td><td rowspan="2">II. Sematic colours.—Warning and signalling colours.</td><td rowspan="4">III. Epigamic colours. — Colours displayed in courtship.</td></tr>
<tr><td>A. Cryptic colours. Protective and Aggressive Resemblances.</td><td>B. Pseudosematic colours. — False warning and signalling colours.</td></tr>
<tr><td>1. Procryptic colours. — Protective Resemblances.</td><td>1. Pseudaposematic colours.— Protective Mimicry.</td><td>1. Aposematic colours. — Warning colours.</td></tr>
<tr><td>2. Anticryptic colours. — Aggressive Resemblances.</td><td>2. Pseudepisematic colours. — Aggressive Mimicry and Alluring Coloration.</td><td>2. Episematic colours. — Recognition markings.</td></tr>
</table>

Thus the facts of mimicry fit into a broad system which includes the other resemblances in organic nature. The relation between protective resemblance (I. A. 1) and protective mimicry (I. B. 1) is as follows:—In the former an animal resembles some object which is of no interest to its enemy, and in doing so is concealed; in the latter an animal resembles an object which is well known and avoided by its enemy, and in doing so becomes conspicuous. Thus mimicry as interpreted by H. W. Bates finds its place in I. B. 1, while the resemblance between protected conspicuous forms (sometimes, but, as I think, erroneously, called mimicry), as interpreted by Fritz Müller ('Kosmos,' May 1879, p. 100, translated by Meldola in Proc. Ent. Soc. Lond. 1879, p. xx), falls into II. 1. Such cases only differ from ordinary warning colours in that they are common to two or more species: hence,

as has been already pointed out, the term *synaposematic* colours, or common warning colours, may be conveniently applied to them.

The arguments in favour of natural selection as the explanation of protective resemblance run entirely parallel with those which favour it as the interpretation of mimetic resemblance and common warning colours. By modifying the examples and, in some cases, the form of the argument, nearly every section of this paper might be converted into a defence of the former, and the arguments which are strongest in support of the one are the strongest in support of the other, viz. those contained in Sections 4, 5, 6, 7, 11, and 12.

Under the theory of natural selection all the resemblances among animals, mimetic and other, show the clearest relationship, and (with the exception of the debated Epigamic colours) are to be explained by the working of a common principle, viz., the selection of variations which are useful in the struggle for existence. Under the other theories mentioned above no such grouping can be readily brought about, and mimetic resemblance becomes due to one set of principles and the other resemblances to another set. The majority of those who look on mimicry as due to external or to internal causes, or to sexual selection, would probably agree in explaining protective resemblance by natural selection. And yet these latter cases, while far more common, are often as detailed and as remarkable as those of mimicry. Those who adopt the most extreme form of the theory of external causes might perhaps maintain that the resemblance to twigs, leaves, and bark is to be explained in the same manner, and would thus bring protective and mimetic resemblance under the operation of the same set of forces; but few will be prepared to carry the theory so far. Under the theory of internal causes it is impossible to bring the two kinds of resemblance together; for while it is held by some that two or more animals may independently and without selection arrive at corresponding points in their evolutionary history, which are such as to involve mimetic resemblance, no one could believe that the similarity to bark or earth has been produced in the same manner. Those who are inclined to accept sexual selection as the explanation can only bring the two classes of facts together by supposing that the appearance of some minute portion of the total vegetable or mineral environment has acted as a stimulus and has led one sex to select the other

according as it resembled the object in question; just as a similar selection has been supposed to take place from the stimulus supplied by the appearance of another species. Probably no one is prepared to adopt this view as regards the former class of facts, although Darwin had, as the above-quoted letter shows, considered the possibility of the general tints of the environment influencing the trend of sexual selection in this way.

A fatal objection to any explanation based on the theory of sexual selection is the fact that protective resemblances are so extremely common and perfect in the immature stages of insects. The same objection holds, although with less force, against its use as an explanation of mimetic resemblance.

The conclusion appears inevitable that under no theory except natural selection do the various resemblances of animals for their organic and inorganic environments fall together into a natural arrangement and receive a common explanation. On any theory except natural selection this can only be brought about by the adoption of extreme views as to the area over which the alternative theory is to be applied,—views which, at any rate, the great majority of those who are disposed thus to explain mimetic resemblance are not prepared to adopt.

(4) *Mimetic Resemblance and Common Warning Colours between different Arthropod Classes and between various Insect Orders, and their Relation to Similar Resemblances within the Limits of a Single Order.*

The discussion at the Entomological Society was based almost exclusively upon the phenomena presented by mimetic resemblance and common warning colours affecting the species of a single Order of insects (Lepidoptera), and generally the species of a single Family (*Nymphalidæ*). I cannot but think that this limitation of the survey to one small part of the field over which the resemblances commonly occur is, in large part, the cause of the rejection of natural selection and the substitution of alternative suggestions. There is something attractive and plausible in the suggestion that the strong mutual resemblances within a group of butterflies of different genera and subfamilies, inhabiting a single locality, are due to the direct action of peculiar local physical or chemical influences; but the suggestion loses all its attractiveness when it is applied to the resemblance between a

spider and an ant, or a moth and a wasp. And yet few could bring themselves to believe that the resemblances which are here contrasted have been built up by two entirely different sets of forces. Mr. Blandford alluded to this relationship and gave it as his main reason for accepting Bates's theory, although he rejected the Müllerian theory of Common Warning Colours. This discrimination in favour of the former theory is not justified by the facts. The resemblance between different insect orders has not been as yet sufficiently regarded from the Müllerian standpoint; but there are, and have been for many years, the strongest indications that here also much of the ground formerly believed to be covered by the older theory will be found to be occupied by the newer.

The Müllerian theory by no means demands that the methods of defence in the members of a convergent group should be uniform.

So long ago as 1887 ("The Experimental Proof of the Protective Value of Colour and Markings in Insects in reference to their Vertebrate Enemies," Proc. Zool. Soc. 1887, pp. 191–274) I tabulated the colours and markings of all insects which up to that time had been experimentally proved to be specially defended, and was enabled to apply to the whole group of conspicuous insects the explanation offered by Fritz Müller (*l. c.* p. 227). This general conclusion will be found to be supported by many facts and considerations in the paper referred to.

In alluding to the resemblance which the black-and-yellow-ringed unpalatable larva of *Euchelia jacobææ* bears to a wasp, I wrote (*l. c.* pp. 235, 238):—"Thus it is more than probable (as has been previously suggested by other observers) that the species rendered conspicuous by alternate rings of black and yellow gain great advantages from the justly respected appearance of Hornets and Wasps. It must not be forgotten, however, that the latter forms also probably gain to some extent by the greater publicity which follows from the resemblance."

I may here digress for a moment and invite the attention of those who dwell on the excessive amount of assumption in the theories of mimicry, to the numerous tables in the paper mentioned above. In these will be found recorded the whole of the results of actual experiments made, up to 1887, upon the palatability and unpalatability of conspicuous and inconspicuous insects. It may be safely asserted that the theories in question are not nearly

so devoid of support from the results of experiment and observation as has been represented.

Since 1887 further evidence has been forthcoming in support of the Müllerian explanation; for it has been shown in many cases that insects which resemble specially defended members of another order, themselves belong to a specially defended group within their own order. Thus Haase ('Researches on Mimicry,' part ii. London, 1896, English translation by C. M. Child, p. 70) points out that the South-American moths which resemble "immune" Coleoptera—the *Lycinæ*, "belong to the immune families of the *Glaucopidæ* (*Mimica*, *Lycomorpha*) and *Arctiidæ* (*Pionia*)," and also that (*l. c.* p. 73) the South-American *Glaucopidæ* furnish numerous cases of resemblance to Aculeate Hymenoptera. In a note to the same page Haase adduces some little direct evidence for the inedibility of a Glaucopid.

During the past year Dr. L. O. Howard, of Washington, has kindly presented to the Hope Department, Oxford University Museum, a pair of specimens which prove that the protected moth *Lycomorpha latercula* (Edw.) occurs in the same locality and at the same time of the year as the beetle *Lygistopterus rubripennis* (Lec.), which it closely resembles, the former having been captured on June 18, the latter on June 5, 1897, in the Chiricahua Mountains, Arizona, by Mr. H. G. Hubbard.

Furthermore, the resemblance between the species of the two great sections of the order Lepidoptera—the Rhopalocera and Heterocera—is frequently of the Müllerian rather than the Batesian kind. Thus Sir George Hampson has pointed out that the moth *Abraxas etridoides*, resembling the butterfly *Teracolus etrida*, belongs to a specially protected genus, and that similarly three genera of the *Chalcosia* group of *Zygænidæ*, which are said to resemble Danaine and Papilionine butterflies, are also extremely distasteful to insect-eating animals ('Nature,' 1898, Feb. 7, p. 364). Similarly, Mr. Roland Trimen, in his Presidential Address to the Entomological Society (Jan. 19, 1898), points out that the "abundant and extremely conspicuous, slow-flying, diurnal Lithosiid moth *Alætis helcita*," together with its "apparently protected analogues .... the closely similar Lithosiid *Phæagarista helcitoides*, and Agaristid *Eusemia falkensteinii*," show great similarity to the group which is headed by *Danais chrysippus*,—" so that from the aspect of warning of distastefulness to enemies the two sets may be regarded as practically but

one." Similar facts will probably be found in numerous other examples of moths which resemble the butterflies.

It may be safely asserted that, even with our present limited knowledge, Müllerian resemblance, no less than Batesian mimicry, can be found in the species of groups with all degrees of affinity, and that there is no ground for Mr. Blandford's contention that the latter alone derives support from the facts presented by the groups which include species from different orders.

Under natural selection the interpretation of the whole series of facts is perfectly valid. The dominant forms which in each locality move towards each other and towards which less dominant forms also move, are in some way specially defended. The principles are the same when the approximation is between the species of different orders or suborders, or between those which are much more closely related. The Müllerian theory explains the resemblance of such large numbers of stinging insects to each other and of other specially defended forms to them, whether they be closely or distantly related: it also explains the resemblance of the dominant *Heliconinæ* and *Ithomiinæ* in each locality in South and Central America and of other forms to them. Batesian mimicry explains the cases in which the attracted forms are not specially defended.

The conclusion which emerges most clearly is the entire independence of zoological affinity exhibited by these resemblances; and one of the rare cases in which Darwin's insight into a biological problem did not lead him right was when he suggested that a former closer relationship may help us to understand the origin of mimicry. Further confirmation of this conclusion will be found in the additional details supplied in the succeeding section.

When we look at the phenomena of mimicry and common warning colours as a whole, it is found that the theory of natural selection is equally applicable throughout; while the theories of external causes and internal causes cannot be applied to some of the most striking resemblances, those of moths, beetles, and Diptera to stinging Hymenoptera. The theory of sexual selection is less logically assailable on these grounds; but with the other two suggested substitutes for natural selection, it entirely fails to account for the attractive force exercised by specially protected forms. Under any of these three theories it is a mere coincidence that the insects which are resembled by species of all

kinds happen to possess stings—that the central types in the groups of butterflies belong to subfamilies which are more abundant and even more unpalatable than the generality of their order. It is, furthermore, a mere coincidence that such groups are formed round the *Danainæ* and *Acræinæ*, *wherever they occur in all the warmer regions of the world*, and in tropical America also round the *Ithomiinæ* (*Neotropinæ*), which are closely related to the former, and the *Heliconinæ*, which are closely related to the latter.

No theory except natural selection explains why the number of colours and patterns in the dominant groups of butterflies mentioned above are so few in relation to the number of species, as was pointed out by Prof. Meldola (Ann. & Mag. Nat. Hist., Dec. 1882). These colours and patterns have been recently studied very carefully, especially in the *Ithomiinæ*, by A. G. Mayer (Bulletin of the Mus. of Comp. Zool. at Harvard Coll., Feb. 1897, p. 169). Mayer shows that "the 200 species of *Papilio* in South America display 36 distinct colors, while the 450 species of *Danaoid Heliconidæ* [*Ithomiinæ*] exhibit only 15. Hence the numbers of the *species* and of the *colors* are almost in inverse ratio in the two groups. This may be explained by the fact, that the *Danaoid Heliconidæ* mimic one another, while the *Papilios* do not...... There is no lack of individual variability among the species of the *Danaoid Heliconidæ*; yet the species as a whole vary but little from the two great types of color-pattern represented by *Melinæa* and *Ithomia*. In order to account for this remarkable fact, I am forced to resort to Fritz Müller's theory of mimicry" (*l. c.* p. 229). Again on page 225 Mayer remarks: "It is difficult to account for the remarkable conservatism in respect to color-variations among the *Heliconidæ* [here used, as in Bates's original paper, to include *Danainæ*, *Ithomiinæ*, and *Heliconinæ*], unless we resort to the explanation afforded by the theory of mimicry; for, while there is such remarkable simplicity and uniformity of color-pattern throughout the whole group of the *Heliconidæ*, *individual variations* are very common."

It is not from any predisposition or bias in favour of natural selection that these conclusions are reached, but simply because natural selection offers an explanation of so many remarkable facts which are utterly meaningless under any other theory yet brought forward.

(5) *Resemblances even within the Limits of an Order are entirely independent of Affinity.*

The entire independence of affinity is specially well seen in the groups of convergent moths and butterflies which are found in different localities in South America. Although the resemblance is clear enough in all the members of a large group, it is far closer in certain species than in others. When these are examined they are found not to be more nearly related than other members of the group, but frequently the reverse. Thus it is very common for a species of *Heliconius* to resemble with the most remarkable precision a species of *Melinæa* or some other Ithomiine genus in its locality. Such resemblance is in these cases far closer than that of the former to the species of the other genus (*Eueides*) in its subfamily, and than that of the latter to any species in the numerous related Ithomiine genera. Thus, to illustrate this conclusion from some examples in the Hope Collection, in Honduras by far the strongest resemblance is to be found between a *Heliconius* and a *Melinæa*; and this is also the case (both species being different) in Surinam. In Trinidad the resemblance is closest between a *Heliconius* and a *Tithorea.*

Under the theory of natural selection this association is readily explicable. The pairs which thus form the centres of local groups are probably the dominant forms, relying more completely than the other members upon the defence afforded by their warning colours and the associated unpalatability. As a matter of fact there is some evidence for their exceptional abundance as compared with the other members of their groups. Again, they are usually more nearly of the same size than the other members, so that the perfection of the resemblance in colour and pattern is aided by resemblance in another quality.

The theory of external causes entirely fails to account for these facts. Uniform local conditions, if they can produce any effect at all, must be expected to produce the closest likeness where there is the closest constitutional similarity—in other words, in the more nearly related forms, in preference to the less nearly related, in each locality. With the theory of internal causes we should also expect the facts to be the reverse of those which exist. At the best it is unable to account for the observed phenomena.

Any theory of selection (natural, artificial, or sexual) affords a

logical explanation of the facts, in the sense that it is quite conceivable that the observed results might be thus obtained. Hence the objection to sexual selection as a suggested cause is not as strong as the objection to the other causes which have been brought forward. Nevertheless, I believe that very few will be found to support the former suggestion.

The conclusions here arrived at by a consideration of the facts presented by the Lepidoptera are entirely confirmed by those already known in the Coleoptera; although as yet but little attention has been paid to the latter Order in this respect. Mr. C. J. Gahan, in an interesting paper (Trans. Ent. Soc. Lond. 1891, pp. 367–374), clearly shows that the Phytophagous genus *Diabrotica* is in the same position as the large protected groups of butterflies already mentioned (*Danainæ*, *Ithomiinæ*, *Heliconinæ*, *Acræinæ*). The individuals of its species swarm in the localities where they occur; they are conspicuously coloured, and many of them are known to feign death when captured and to discharge a yellow fluid from various parts. The facts at present ascertained justify the conclusion that these Coleoptera form centres of Müllerian resemblance, in that "some of the species belonging to one section in this genus are, in colour and marking, extremely like certain species of the other section which come from the same localities" (*l. c.* p. 372). Mr. Jacoby has also "recorded that many of the species of his genus *Neobrotica* exhibit most striking resemblances to species of the closely related genus *Diabrotica*." The latter species are also mimicked by those of the allied genus *Dircema*. Mr. Gahan shows, furthermore, that 18 species of the genus *Lema*, belonging to a different sub-family, closely resemble the species of *Diabrotica* (in one case the allied genus *Cerotoma*) found in the same localities in tropical America. In three cases species of *Neobrotica*, and in one a species of *Dircema*, fall into the groups thus formed.

Mr. Gahan is disposed to regard the resemblance of the species of *Lema*, together with that of the Longicorn *Oxylymma gibbicollis*, for a species of *Diabrotica*, as an example of Batesian mimicry. Future observation and experiment must decide upon this as upon so many other cases concerning which we are uncertain whether to adopt the Batesian or the Müllerian interpretation. The tendency of recent observation, however, strongly favours the opinion that the latter theory will explain a much larger number of resemblances than the former.

But whichever interpretation be ultimately adopted, the fact remains the same—that the resemblances in the Coleoptera are of the same character as those in the Lepidoptera, and are, like the latter, independent of affinity. They are readily to be explained by the operation of a theory of selection, but present the same difficulties as those presented by the Lepidoptera to an interpretation by any other theory as yet brought forward.

(6) *The Resemblances in question are not accompanied by any changes in the direction of another Species except such as assist in the production or strengthening of a Superficial Likeness.*

This argument is fatal to any theory as yet advanced except one based upon the principle of selection directed to a definite end, viz. the production of resemblance. It is impossible to explain why external forces or internal forces should thus act upon a certain set of characters whose only relationship is that they tend to produce a superficial likeness to another species—that they should act upon these alone to the exclusion of all other sets. No assistance can be obtained from the conclusion that the results are recent and therefore superficial, and that a resemblance in deeper characters will follow in time. In the first place, the examples of more perfect (and presumably older) resemblance show no more tendency towards approximation in characters which do not help to produce likeness, than the examples in which the resemblance is comparatively rude (and presumably recent in origin). In the second place, deep-seated parts of the organism *are* affected when the superficial resemblance is thereby increased, but not otherwise. To take a single example, the common British Longicorn *Clytus arietis* strongly suggests the appearance of a wasp, partly because of its black and yellow banding, but even more because of its alert and wasp-like movements. This implies, of course, appropriate changes in its nervous and muscular systems.

There are many cases, like that of *Clytus*, in which the changes in deep-seated structures are of more importance than anything else in determining the resemblance. I know of no more striking example of this than the movements and attitudes of the young (Lepidopterous) larvæ of *Endromis versicolor*, which render them extremely like the larvæ of saw-flies (Phytophagous Hymenoptera). Numerous experiments have convinced me that

the latter are almost invariably distasteful. I exhibited the former larvæ in the second stage at the Entomological Society on June 3, 1891. The following account is given in the Proc. Ent. Soc. 1891, p. xv:—"At this period [viz. the early stages of growth] the larvæ arrange themselves in small groups upon the leaves and leaf-stalks of the birch, and when disturbed they raise the anterior part, bending the head over the dorsal surface of the posterior part of the body. In this attitude they strongly remind the observer of those Tenthredo larvæ which, when irritated, bend the tail forwards over the anterior part of the body. The fact that the head is raised in the one, and the tail in the other, does not cause any conspicuous difference when the larvæ are seen from a little distance. The common Tenthredo larva, *Crœsus septentrionalis*, is about the same size as these small Lepidopterous larvæ, feeds in similar small groups when large (when small the groups contain far more individuals), and also frequents the birch." In my experience, however, the *Crœsus* feeds much later in the year. Mr. W. Holland also noted the same resemblance in the 'Entomologist's Record' for Oct. 15th, 1891 (see vol. ii. p. 228). Mr. Holland has also kindly lent me his notes made at the time, and I see that he observed the saw-fly-larva-like movements which follow disturbance. The groups have never been figured before, so far as I am aware. In May 1896 we reared some larvæ from the egg in the Hope Department, and I was able to get some excellent coloured drawings by Mr. P. J. Bayzand. These drawings, reproduced on Plate 40. figs. 2 & 3, show the attitude taken up on disturbance better than any description. They also prove that, like the saw-fly larvæ, the groups contain far more individuals in the younger stages than later. The conspicuous orange-coloured true legs suggest the appearance of the orange ventral glands of the *Crœsus*, which are everted when the larva is irritated.

Thus the causes of the resemblance we are discussing may be deep-seated or may be superficial, or, more generally, may be due to several kinds of causes in each category. It is in the latter extremely complex cases, and these are far the commonest, that the argument for natural selection becomes irresistible. This will be more thoroughly dealt with in the succeeding Section; but even in the case of the simplest element in the resemblance, viz. the similarity in colour and pattern taken alone, the theories

of external and internal causes are unable to offer an adequate explanation of certain facts which are clearly explicable by natural selection. In the males of the Pierine group *Dismorphina*, the long-and-narrow-winged appearance of an Ithomiine butterfly is largely produced by the excessive overlap of the upper upon the under wings. This results in the concealment of a large part of the upperside of the under and of the underside of the upper wing; and it will be found that the mimetic patterns are withheld from these hidden surfaces, which often retain some distinct trace of the old Pierine character, viz. an opaque white appearance.

The male of *Dismorphia praxinoe* is shown on Plate **40.** fig. 4, the underside in fig. 5; the upper and under sides of the female, for comparison, in figs. 6 and 7. This fact holds true even for such a specialized and perfect mimic as *Dismorphia orise* (see Plate **40.** figs. 8 & 9, for the appearance of the male).

F. D. Godman and O. Salvin, in the 'Biologia Centrali-Americana' (Rhopalocera, p. 173), speak of these hidden chalky patches, surrounded by a silky area covered by peculiar scales, as a character of the *Dismorphina*. The interpretation of the patch as a sexual brand perhaps with the nature of a scent-producing organ, does not in any way disprove the suggestion here adopted—that the white pigment in the scales is a survival from an ancestral condition still found over the greater part of the wing-surface in so many non-mimetic *Pierinæ*, as well as in the males of many mimetic species (*e.g.* in the genus *Mylothris*). It should be noted, however, that the patch is not white in certain species of the *Dismorphina*. Mr. Belt ('Naturalist in Nicaragua,' pp. 384, 385) states that the white patch is usually concealed by the males, as indeed may be inferred from the change in character of the surface, which indicates the normal amount of overlap of the fore upon the hind wing. Mr. Belt also suggested that the white appearance is ancestral and has been retained by the operation of sexual selection.

The restriction of the effects to those parts of the surface which can be seen tells very strongly against any theory which is not based on the principle of selection.

(7) *Essential Nature of these Resemblances: their Analysis into the several kinds of Effect produced.*

The resemblances under discussion are made up of elements

of very different kinds combined in single individuals; but the essentially composite nature of the effect easily yields to analysis. Some of these complex combinations only require to be stated in order to show the inadequacy of the theory which is most usually substituted for natural selection, viz. the theory of external causes.

A mimetic appearance is commonly made up of (1) colour, including (*a*) structural as well as (*b*) pigment colours; (2) pattern; (3) form; (4) attitude; (5) movement.

It may be plausible to hold that direct local influences determine colour, but the case becomes much more difficult when structural tints are included, as they frequently are. Thus it might well be held that the dark pigment of a female *Hypolimnas* and of the *Euplœa* which it resembles are alike the direct effect of the locality they both inhabit. But the most convinced advocate of direct local causes would probably hesitate to explain, by the operation of the same forces, the structurally caused blue sheen which overspreads the dark pigment in some of these mimetic pairs. Similarly with pattern, it is much more difficult to understand the appropriate arrangement of the colours by direct forces than the production of the tints themselves; still more difficult to understand how such forces could modify shape, and again, more difficult to modify the nervous and muscular systems so as to produce appropriate attitudes and movements. Most difficult of all to understand, except on a theory of selection, how the several elements in the complex set of changes could be kept in their proper relationship and guided to a definite end, viz., the production of a superficial resemblance to another species.

The objection to the theory of internal causes is not that it is inadequate to produce each of the effects, but that it is in the highest degree improbable that so complete and harmonious an effect could be frequently produced accidentally by the combination of such diverse elements.

When, therefore, it is argued that these resemblances are the uniform result of uniform forces peculiar to the locality, investigation proves that the results are very far from uniform. They appear at almost any point in the structure of the body, superficial or deep-seated, generally at many points in a single individual both superficial and deep-seated, and the only common bond which can be established between the various elements

which make up the common effect is that they all co-operate in producing superficial resemblance to some other species.

It is here shown that the changes wrought in a single species are far from uniform. It will be shown later on (see Sections 11 and 12, pages 585 to 602) that there is frequently no uniformity in the methods made use of by mimic and model, nor any uniformity between the various mimics of the same model, nor between the different members of a synaposematic group. These, too, often have only one thing in common, and that inexplicable except on a theory of selection, viz. the subordination of all these divergent methods to a single end—the attainment of a superficial resemblance.

The arguments in this and the preceding Section are equally powerful in support of the interpretation of protective resemblances as due to natural selection.

Again, mimetic resemblances are comparatively rarely seen in more than one stage of insect life, and are, in the great majority of cases, restricted to the final stage. In all such species the total appearances presented by the final stage, including mimetic resemblances, are prepared for in the earlier stages, and especially the larval. Not only are the changes in question confined, as has been pointed out in the earlier parts of this Section, to the parts, tissues, and organs which affect the superficial appearance, but they are also generally confined to the final stage of insect life. During larval life the foods peculiar to the locality are devoured and the material for the mimetic stage is stored up. The larval and pupal stages are together, in the great majority of cases, far longer than the imaginal stage, and are no less, and, as regards food, far more, subject to the direct action of the forces peculiar to the locality. On what theory except natural selection is it possible to explain the rigid limitation of these changes, in so large a proportion of cases, to the final stage, and their entire exclusion from the stages in which they are, in the history of the individual, predetermined?

(8) *Conditions of a Species in any Locality are chiefly determined by its Habits and Life-history.*

In the last Section it was shown that there is no uniformity in the effects produced in any locality. In this Section it will be made clear that there is no uniformity in the forces which, by

their uniformity, are supposed to produce the effects. When we are told that common food, common climate, &c. produce a common effect, we have the means for proof or disproof in, at any rate, some striking examples; for we know the food and conditions of certain species which exhibit mimetic or common warning associations. There are many examples of Longicorn beetles mimicking *Lycidæ* (Malacoderm beetles) in the same locality; but during the earlier stages, in which the appearance of the final stage is determined, the former lives in a burrow, feeding upon wood or the tissue of plant-stems, and sheltered from many of the climatic influences and changes, while the other lives in the open, freely exposed to them all, and sustained by an exclusively carnivorous diet. I owe this suggestive comparison and the Section which arose out of it to a conversation with Mr. C. J. Gahan, of the British Museum. Similarly in the case of S. American moths belonging to the *Castniidæ*, which resemble Ithomiine butterflies (see Section 12, page 598), the larvæ of the former burrow in plants, while the latter are freely exposed on the leaves which form their food.

It is hardly necessary to insist on the importance of the *larval* stages in this respect. When the imago emerges from the pupa and its expanded wings have dried, it has assumed its permanent appearance, and nothing that it will eat or endure henceforward produces any further effect upon its colours or patterns, &c. Hence identity of food and conditions during the final stage cannot be of any assistance in the interpretation of mimicry. It is necessary to point this out clearly, inasmuch as Beddard ('Animal Coloration,' London, 1892, p. 232, footnote) has said, speaking of the resemblance between *Eristalis*, the drone-fly, and the hive-bee, "It is an interesting fact, in connexion with the resemblance between this fly and a hive-bee, that it feeds upon pollen and honey. This fact *may* have some significance in relation to the effects of food upon form and coloration." But the larva of *Eristalis* stores up nutriment, out of which the final form is built, by feeding on putrefying animal matter, a food as different as possible from that provided for the larval bee. The peculiar conditions under which the larvæ of stinging Hymenoptera obtain their food invariably contrast strongly with the larval condition of their numerous mimics. We find in this Section, as in the others, that the suggested interpretation of these resemblances as the common effect of a common cause or set of

causes breaks down the moment it is analysed. The view is a superficial one, and cannot be sustained when the slightest attempt is made to understand the nature of the phenomena it professes to explain.

(9) *Mimetic Resemblance and Common Warning Colours more characteristic of the Female than the Male Sex.*

These resemblances are far commoner in females than males, and when the two sexes differ in the closeness with which a likeness to some other form is brought about, it is the female which always attains the greater perfection. Examples of mimetic females with non-mimetic males are extremely abundant, being in fact a high proportion of all the cases which occur; examples of the converse relationship are very nearly unknown. These general statements hold with common warning colours as well as with truly mimetic species; they are equally true in all the warmer parts of the world where examples of mimicry are well known and abundant.

In the numberless cases in which a non-mimetic male is attended by a mimetic female, the former bears the ancestral appearance, so that when we pass to a land where both sexes of the representative species are non-mimetic, *both* resemble the non-mimetic male of the former species. In a long series of related species, moreover, the males are found to be nearly alike, while the females diverge in all directions after the species which serve them for models. Furthermore, the females, by reversion, are in rare instances brought back towards the ancestral type represented by the males.

It is hardly necessary to point to examples, for these general principles will probably be at once conceded by any who have made a study of the subject. I may, however, allude to the non-mimetic *Papilio meriones* of Madagascar and the related forms with similar males but widely different mimetic females on various parts of the mainland of Africa; to the general resemblance between the males of so many forms of *Hypolimnas* of the *bolina* group to each other and to those of *H. misippus*, &c.; to the varying degrees of reversion towards the appearance of the male presented by occasional females of *Hypolimnas bolina*.

These relationships are the reverse of those which usually

obtain. Outside these resemblances it is the rule, when any difference between the sexes exists, for the female to show us the ancestral type, the male the more modern development; and the male in growth from youth to maturity generally passes through the condition permanently retained by the female.

No probable interpretation of these unusual relationships can be offered by any theory except natural selection. The theory of external causes demands the improbable hypothesis, for which no evidence can be found, that the female of mimetic species (but not of others) is constitutionally more ready to respond to the direct action of external forces than the male, and that the difference is commonly great enough for the female to have given a complete and detailed response, when the male, subject to the same direct forces, does not exhibit the faintest trace of the operation of any such influence.

The facts are equally inexplicable by the theory of internal causes—and not inexplicable only, but the reverse of what we should expect; for, as I have already stated, it is the female which, outside these resemblances, tends to retain the ancestral form.

The theory of sexual selection also fails to account for the facts. If it were valid, the selection would be that of the male, for these recent developments are specially characteristic of the other sex. In other cases in which male rather than female selection is supposed to have acted in the production of colour or pattern in butterflies, there is some direct evidence derived from the observation of courtship; but here no such support is forthcoming.

Under the theory of natural selection the facts at once receive an explanation. Wallace suggested long ago that the slower flight of the females "when laden with eggs, and their exposure to attack while in the act of depositing their eggs upon the leaves, render it specially advantageous for them to have some additional protection." In animals which are hidden by protective resemblance, similar causes explain why the female is so often better concealed than the male. In birds the dangers of incubation balance the dangers of egg-laying in insects. But protective resemblances are less special than cases of mimicry in the sense that the models (bark, twigs, leaves, &c.) are more generally alike throughout all countries, and less rapidly change their distribution than the models of mimicry and

the dominant types of common warning colours. These and other reasons, such as the great number and wide geographical range of species belonging to the same genus and adopting a single method of concealment, compel the belief that examples of protective resemblance are extremely ancient in the past history of the species as compared with examples of mimicry, so that we can well understand how it is that in the former, when the female differs it is ancestral as compared with its male, while in the latter the converse relationship obtains, and the appearance presented by the male is comparatively ancestral.

The main conclusion which emerges is that the advantageous is the thing that is attained. If an ancestral appearance is advantageous it is retained, especially in the sex that needs it most; if a new appearance is advantageous it is attained, especially by the sex that needs it most. The female sex becomes conservative or progressive according to the needs of the species, and natural selection is limited by no bounds of constitutional difference between the sexes as regards the preservation of the old or the initiation of the new.

(10) *The Space and Time Relationships of the Resemblances in Question.*

A mimetic group is found in the same locality, or at least the mimic (Batesian) is not found beyond the range of its model. The types of Common Warning Colours are remarkably local, although probably certain members of the group (being *ex hypothesi* all specially protected) may sometimes have a wider range than others. When such a mimic as *Hypolimnas misippus* can invade and thrive in South America and the Antilles in the absence of its model (*Limnas chrysippus*), we probably have to do with a Müllerian rather than a Batesian association (see also a paper on Mimicry in the Genus *Hypolimnas* by E. B. Poulton in Report Amer. Assoc. for Adv. of Sci., Detroit Meeting, 1897, where other arguments in support of this conclusion are urged).

Looking at the examples broadly the phenomena are characteristically local. This, although harmonizing with the other suggested explanations, is quite unintelligible if the theory of internal causes be adopted. Why should these results if attained independently in the evolution of various forms be attained in the same locality? The number of patterns and the number of forms is so vast that we must expect a certain amount

of accidental resemblance due to internal causes, as has been suggested by Beddard ('Animal Coloration,' London 1892, p. 252); but such resemblances will differ from those under discussion in this among other things—that they will not be characteristically local. The theory of internal causes offers us a valid interpretation of such cases, which are, as a rule, readily distinguished from those which are here considered.

There is another aspect of locality which only receives an explanation on the theory of natural selection. Why should examples of mimicry and common warning colours be so much more abundant and perfect in one country than another? The physico-chemical influences, the effects of luxuriant vegetation, as Wallace has pointed out, are very similar in tropical S. America, Malaya, and W. Africa, and yet the first-named country is pre-eminent in affording examples of the resemblances under consideration. This is not only true of likenesses within the Order of Lepidoptera, it appears to be equally true within the Coleoptera; it is true of the resemblances of moths to wasps. It is even more marked in Müllerian resemblance between protected forms than in the examples of Batesian mimicry. If the direct action of forces connected with locality cannot explain the immense predominance of tropical South America in this respect, we are driven to enquire whether insect-life is especially luxuriant and remarkable in this part of the world, and whether it is not probable that the struggle for existence is especially keen. There is no doubt about the answer to the former question; the variety, peculiarity, and abundance of insect life is far greater than in any other part of the world, and it is a fair inference that the conditions are in an equally marked degree favourable for rapid and complete modifications under the operation of natural selection.

We have not as yet sufficient evidence that mimetic groups and groups with a common warning coloration appear at the same time of the year. Such evidence as we have points in this direction. The rarity of the mimetic species is usually stated to be due to their being lost in the swarms of the abundant model. There are a large number of cases in which the forms have been caught together by a collector who has passed a limited time in a given locality.

We are collecting at Oxford as many examples as possible of such species, captured upon the same day in the same place.

This series, which we intend to keep separate, when more complete, will afford very valuable evidence on this point. Already it proves that the members of the groups which converge round *Limnas chrysippus*, *Amauris echeria*, and the black and white species of *Amauris* in Natal are upon the wing together. This evidence has been very kindly supplied me by Mr. Guy A. K. Marshall. I have similar, but less complete, evidence as regards some of the Central and S. American groups.

It will probably be conceded that the phenomena generally are likely to exhibit the same relationship in time which has been already proved to exist for many of them. This conclusion, however, is a considerable difficulty in the way of the theory of external causes as well as a further difficulty to the theory of internal causes. As regards the latter, the time relationship is an entirely unexplained coincidence; as regards the former, it is a coincidence which leaves much to be explained. It is difficult enough to believe that local forces could produce local resemblance; it is a further difficulty that the resemblances are contemporaneous. If, as is probable, the forces are supposed to act during larval life, they must include in their effects an influence on the rate of growth and development, an adjustment of the duration of stages delicate enough to bring the various species into the phases in which the resemblance is shown at similar times of the year. But such effects are entirely different from those which are manifest in the resemblance itself, and add a further complexity to a result already shown to be so complex that the theory of external causes fails to supply an interpretation (see Section 7, p. 576).

But it has been shown in many cases, and is probably true in all, that the time relationships between the species which exhibit these resemblances are not confined to their appearance at the same season of the year. They are such that they fly together under those conditions of light which render the resemblance visible to enemies. When moths resemble butterflies, they are mostly species which are as truly day-flying as the butterflies themselves; in other cases they are species which fly readily by day when disturbed. Similarly with the species of various orders which resemble Hymenoptera. The case of Coleoptera recently suggested to me by Mr. Gahan is peculiarly interesting. It is known in so many cases that beetles which are about by day possess finely facetted eyes as compared with the larger fewer

facets of the nocturnal species, that it is possible to infer the habits from the structure of the eyes. Thus the species of the Longicorn genus *Doliops* (family *Lamiidæ*), which closely resemble weevils (see p. 596), are, judged by this standard, diurnal in their habits. The case is all the more interesting, inasmuch as such an eye-structure, such habits, and such mimicry is quite exceptional in the group, the *Niphoninæ*, to which the genus belongs.

The facts recorded above imply such a resemblance between the nervous systems and sense-organs of the various species as will make them diurnal (or in some cases semi-diurnal) in their habits. This constitutes a further grave difficulty in the way of any explanation based on external or internal causes. If the diurnal habits are supposed to be due to such causes, the vastly increased complexity of the result is the difficulty. If the resemblances are supposed to be thus produced only in the species which are already diurnal, it is impossible to explain why the external or internal forces are thus restricted in their operation.

It is hardly necessary to point out that the time and space relationships, which are such a difficulty in the way of the other two theories, are entirely necessary to the explanation based on the theory of natural selection. If they did not exist it would be overthrown.

(11) *The Resemblances which Insects of various Orders bear to those of another Order are produced in the most Diverse Ways.*

The most common types for mimetic resemblance are those of the wasp and ant. These aggressive, abundant, and successful forms are resembled by insects of various orders. Still more interesting is the fact that the resemblance is produced in the most varied ways.

A superficial resemblance to stinging Hymenoptera is probably more general and is brought about by smaller changes in Diptera than in any other Order of insects. A fly which gains alternate black and yellow rings on its body is at once suggestive of an appearance presented by many common wasps. In more extreme cases, the body gains a constriction presenting a strong likeness to the slender petiole of the wasp's abdomen, there are changes in the manner of folding and sometimes in the colour of the wings, in

the buzz, in the movements of the body (the latter being such as to suggest the power of stinging), and (in the mimicry of hairy humble-bees) in the acquisition of an abundant hairy covering. A good example of a fairly perfect resemblance is shown in Plate **41**. fig. 5 A, an Australian fly, the models from the same part of the world being shown in figs. 5 B and 5 C.

A Hemipterous insect requires the most profound modification in the shape of its flattened un-wasp-like body, and in the display and characteristics of its wings. Corresponding to these much greater initial differences, the resemblance is *much* rarer than in Diptera. A beautiful instance is shown in Plate **41**. fig. 1, a Hemipterous insect—a species of *Myocoris*, probably *M. braconiformis* (Burm.)—which is extraordinarily like fig. 2, not, in this instance, a wasp but an ichneumon, using the term in the broad sense; for the species belongs to the *Braconidæ* and is probably an *Iphiaulax*. Although the two specimens in the British Museum, which I have been kindly permitted to figure, did not come from the same part of S. America (the Bug was from Para, the Ichneumon from Ega), the resemblance is so close in every way and the modification of the Hemipteron so extreme and remarkable, that there can be little doubt as to this being a genuine case of mimicry and as to the geographical coincidence of the model and mimic: both may have a far wider range than is shown by the specimens which have been figured *.

A Lepidopterous insect requires above all to gain transparent wings, and this in the most striking cases that have been studied is produced by the loose attachment of the scales, so that

* Since the above sentence was written I have searched the collections in the British Museum for further examples, with the help of Sir George Hampson, Mr. C. J. Gahan, and Mr. W. F. Kirby. We found that the type of appearance represented in Plate **41**. figs. 1 and 2 is common and widely distributed in S. America, forming a group which includes many species of *Braconidæ* and of Hemiptera which resemble them. Many figures of such insects presenting this type of appearance are to be seen in the plates of the 'Biologia Centrali-Americana.' In the distasteful group of moths, the *Syntomidæ*, two species are obviously similar, viz., *Leucotmemis varipes* (Walk.) from Para, and *L. tenthredoides* (Walk.) from Ega. *Myocoris braconiformis* is recorded from Surinam as well as from Para.

The co-existence of species of Aculeate Hymenoptera, Hemiptera, and distasteful Heterocera, suggests that the group as a whole is distasteful or specially protected, and is an example of common warning colours. Many other members of the group will probably be recognized

they easily and rapidly fall off and leave the wing bare except for a marginal line and along the veins (*Hemaris*, *Trochilium*). In other cases again (certain *Sesiidæ*) the scales may remain on the wing, but themselves become transparent. In the numerous more perfect instances the body is banded, and may gain a marked "waist," while the scales upon it may be lost or modified, so that the appearance of the hard shining body of the model is suggested with extraordinary exactness.

The means adopted among Coleoptera, even in closely related genera, are so curiously different that a longer description, accompanied by several illustrations, is necessary.

The following examples are all selected from the Longicorns. The simplest resemblance to a wasp is that attained by the common beetles of the genus *Clytus*, such as the British *C. arietis*. A better example is the Mediterranean species *Plagionotus scalaris*, shown on Plate **41**. fig. 3. In these cases there is nothing visible to represent the wings of a wasp; but the elytra and thorax are black banded with yellow, there is a far more pronounced "waist" than is usual in Coleoptera, the legs are slender and wasp-like, and are moved with wasp-like activity and jerkiness. In spite of the apparent want of wings, the effect produced is very considerable, and many persons hesitate to touch the insect. This, then, is the method adopted in the group of *Clytinæ*; but in various other allied tribes, such as the *Necydalinæ*, the *Rhinotraginæ*, the *Esthesinæ*, the *Callichrominæ*, and others, the elytra, which form by far the largest part of the visible dorsal surface in the *Clytinæ*, become greatly reduced so as to show the under wings, which, folded over the back or expanded in flight, in either case strongly suggest the wings of a wasp, or in some cases an ichneumon. Furthermore, the elytra are reduced in two different ways—in some genera to linear rudiments more or less broadened at their bases; in others to small subquadrate or oval structures representing the bases alone. Good examples of the latter are seen in *Esthesis ferrugineus* (*Esthesinæ*) (Plate **41**. fig. 5) from Australia, and in *Nothopeus hemipterus* (*Callichrominæ*) from the Oriental Region (see fig. 4). Examples of the former are shown in *Isthmiade braconoides* (*Rhinotraginæ*), fig. 6, from Brazil, and in a *Hephæstion* sp. (*Necydalinæ*), fig. 7, from Chili.

The examples figured are merely a few selected from a large number, but they serve to show the different degrees to which a

mimetic resemblance is carried, and the very different methods employed, in a nearly related set of insects.

The Hymenoptera, which form the models of these insects, have not been worked out in many of the instances. In the case of *Esthesis ferrugineus*, however, two Aculeate Hymenoptera of very different form, although belonging to the same large group—the *Eumenidæ*, which inhabit the same region (Australia), have a colouring and pattern which are superficially very similar to those which the Longicorn has attained; while a Dipterous insect, an Australian species of *Dasypogon* (*Asilidæ*), also appears to fall into the group. The appearance of the three latter insects is represented in Plate **41**, the dipterous insect being shown in fig. 5 A, the wasps in fig. 5 B, *Abispa australis* (Smith), and fig. 5 C, *Eumenes Latreillei* (de Sauss.). These three figures were drawn from specimens in the British Museum, kind permission having been accorded to me to figure them for the purpose of this memoir. Future study will probably add many species to this very characteristic group.

We thus find that wasps and allied forms are resembled by species of many groups of insects, and the resemblance is attained in all kinds of different ways.

The numerous mimetic resemblances to the aggressive, abundant, and well-defended ants supply an even better illustration. In the majority of cases the whole body of the mimetic form is moulded from the ancestral shape, which is still exhibited by its non-mimetic allies, into that which is characteristic of an ant. In some groups this means a large amount of alteration, in others less. In this case, too, the resemblance extends to species which are altogether outside the Insecta; for many small species of spiders closely mimic ants. In the family of *Attidæ* alone, and such resemblances occur in several other families of spiders, George W. and Elizabeth G. Peckham state (Occasional Papers of the Natural History Society of Wisconsin, vol. ii., 1892, Milwaukee; see also a paper by the same authors in vol. i., 1889) that about a hundred ant-like species are known from various parts of the world, and that they are "very much more numerous in South America and in the Malay Archipelago than in any other countries," viz. in the very countries in which other examples of mimicry are especially abundant. The spider with its two-fold division of body is often made to assume the appearance of an ant, with its three-fold division, by a constriction which

sometimes crosses the cephalothorax, sometimes the abdomen. The absence of antennæ in the spider is known to be compensated in some of the species, which have been studied in the living state, by the habit of holding up one pair of legs, while the walking legs are thus reduced to the ant-like number of six. Of two well-known North American species, *Synageles picata* holds up the second pair, and *Synemosyna formica* the first. The habits of seizing and dealing with prey, and the movements generally are extremely un-spider-like and most suggestive of ants; so that the nervous and muscular systems, as well as the body-form, have been modified. The remarkably ant-like appearance of these two species is shown in the adjoining fig. 1 (A and B).

Fig. 1.

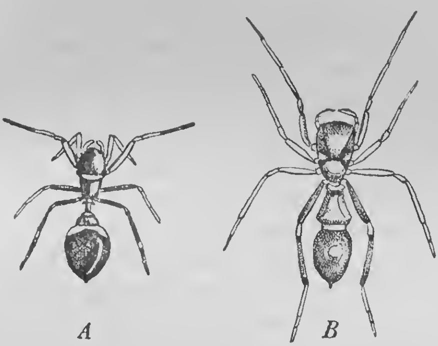


Fig. 2.

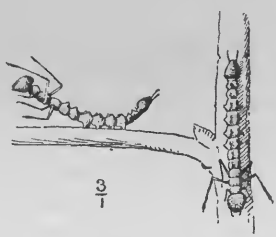


Fig. 1.—Two North-American Attid spiders which resemble ants. A is *Synageles picata*; B, *Synemosyna formica*. (From G. W. and E. G. Peckham, Occasional Papers of the Nat. Hist. Soc. of Wisconsin, vol. i. 1889, pp. 110 & 112.)

Fig. 2 (× 3).—The young larva of *Stauropus fagi* seen from above and from the left side.

Among the Insecta, too, there are many examples of an ant-like appearance brought about by changes of the same kind as those mentioned above, although less marked because the forms to be approximated are less essentially different. Among the Lepidoptera the young larvæ of a British moth, *Stauropus fagi*, have often been described as resembling ants. The likeness has recently been analysed in much detail by Portschinski ("Coloration marquante et Taches ocellées," V.: St. Petersburg, 1897, p. 44). This acute observer considers that the head of the

larva represents the globular abdomen of the ant, while the head and antennæ of the latter are suggested by the larval caudal shield with its two appendages. He believes that the disturbed larva represents an ant which has seized and is endeavouring to carry off some object on the branch which it is exploring. Under these circumstances the head of the ant, with its mandibles fixed in the object, would be held low and remain motionless, while the abdomen would be elevated and the legs in constant activity, moving the posterior part of the body from side to side. Such an appearance and such movements, he maintains, are strongly suggested by the disturbed larva if we only identify the posterior end of the one with the anterior end of the other, and *vice versa*. I have to thank Mr. W. R. Morfill for very kindly translating the memoir of the Russian naturalist. During the present summer (of 1898) I have had the opportunity of studying these larvæ. The young larvæ were thought to be ants by all the friends to whom they were shown. One lady considered that they were "double ants"—an interpretation evidently due to their disproportionate length and to the head-like appearance of the caudal shield. Drawings of the larvæ at this stage were made by Mr. P. J. Bayzand and are reproduced in fig. 2 (p. 589), but they fail to convey the ant-like appearance which depends so largely on movement. A better effect is produced by Mr. Bayzand's coloured drawing which is reproduced on Plate **40**. fig. 1. I should add that I did not observe any attitudes which support the details of Portschinski's interpretation, nor did I witness the appearances which he figures (*l. c.* p. 45, fig. 21). His comparison of the caudal appendage with a head seemed, on the other hand, to be entirely confirmed.

Turning to other Orders which supply examples of the mimicry of ants, the Hemiptera have perhaps the farthest distance to travel in the modification of their flattened bodies. A beautiful example from East Africa, viz. that of *Myrmoplasta myra* (Gerstaecker), is shown in fig. 3. Gerstaecker states that a single specimen of this insect was sent from Rosako, Usaramo, Aug. 1888, as "an ant," together with two undoubted species of these Hymenoptera (*Polyrhachis gagates* and *Ponera tarsata*). The resemblance between the former species of ant and the Hemipteron, Gerstaecker describes as strong enough to be deceptive. It is brought about, he states, by the short globular abdomen extremely constricted towards the thorax

Fig. 3.

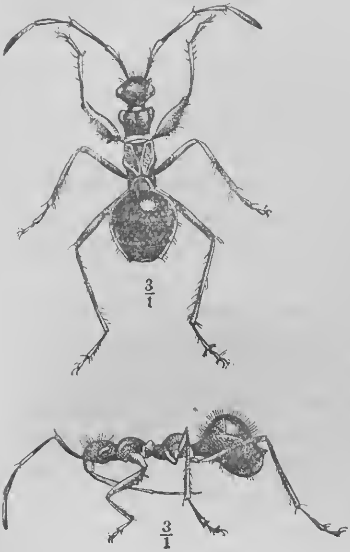


Fig. 4.

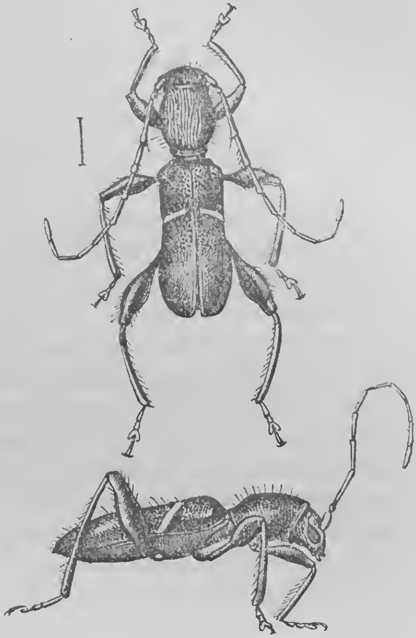


Fig. 3 (× 3).—An ant-like East-African Hemipterous insect, *Myrmoplasta myra* (Gerst.), seen from above and from the left side. (From Gerstaecker, Article 6, Hemiptera, p. 9, in Fr. Stuhlmann's Zool. Ergeb. 1888–1890, Berlin 1893.)

Fig. 4.—An ant-like N.-American beetle, *Euderces picipes* (Fab.), seen from above and from the right side.

(Zool. Ergeb. einer Reise in Ost-Afrika, Fr. Stuhlmann, Bd. I. no. ix. 2; Article 6, Hemiptera, p. 9: Dietrich Reimer, Berlin, 1893).

Among Coleoptera the resemblance to ants is very common. I select as an example a little Longicorn (*Euderces picipes*, Fab.), which I found very abundantly upon the heads of Umbelliferous plants at Pine Lake, Hartland, Wisconsin, in July and August 1897, when visiting Dr. C. A. Leuthstrom. Ants were also very common on the same flower-heads. The appearance and movements of the beetles were extremely ant-like, the suggestion of a stalked abdomen being conveyed by an oblique white line crossing the elytra in a very shallow depression in which the dark ground-colour of the insect appeared to be of a more intense black than elsewhere. The increased darkness was in reality

due to the shadow in the depression combined with the effect of a difference in the texture of the surface. This combination of characters produced a strong superficial resemblance between the elytra of the beetle and the abdomen and thorax of the ant, while the head of the latter was represented by the beetle's head and thorax together. These resemblances are indicated in fig. 4; but the living insect is required in order to recognize them fully.

In all the cases alluded to above, the resemblance is attained by a modification in the form of body and limbs, accompanied by changes in those more deep-seated structures which affect the habits and movements.

There are, however, other very different means by which the same end is attained. One of the most interesting of these is the case of a Locustid (*Phaneropterides*), *Myrmecophana fallax* from the Sudan, described by Brunner von Wattenwyl (Verhandl. der k.-k. zool.-botan. Ges. in Wien, 1883, p. 247). This insect was erroneously described as an Acridian in my paper before the British Association at Toronto (Report, 1897, p. 693, l. 3). Brunner's two figures are reproduced as the adjacent fig. 5. Upon the stout body of this insect the slender-waisted form of an ant is represented in black pigment, the remainder of the body being light in colour and probably invisible against a similar background. Of the habits of the insect nothing is known, but the method is of great interest, being so entirely different from that adopted by any other insect as yet described. In a more recent work ('Observations on the Coloration of Insects,' English translation by E. J. Bles, Leipsic, 1897, p. 11), Brunner von Wattenwyl again alludes to this example, and states that the form of the species "leads to the conclusion that it lives on the ground," viz. in the position which gives a meaning to the resemblance. In spite of this he asks, "Is this imitation an accidental freak of nature?" If *Myrmecophana* were the only example of such resemblance the question might fairly be asked, but in view of the numerous other equally close resemblances to ants, produced in various ways, it is quite unnecessary. The suggestion of an "accidental freak" can never explain such close likeness, in appearance, in movements and habits (so far as they are known), in locality—a likeness, furthermore, not to any insect in the environment, but to insects of a specially successful and aggressive group—a likeness not produced in one way but

in many different ways. To suggest an "accidental freak" as the explanation shows an amazing credulity, only to be explained by the bias which is ready to accept ANY interpretation except that afforded by the theory of natural selection.

Fig. 6.

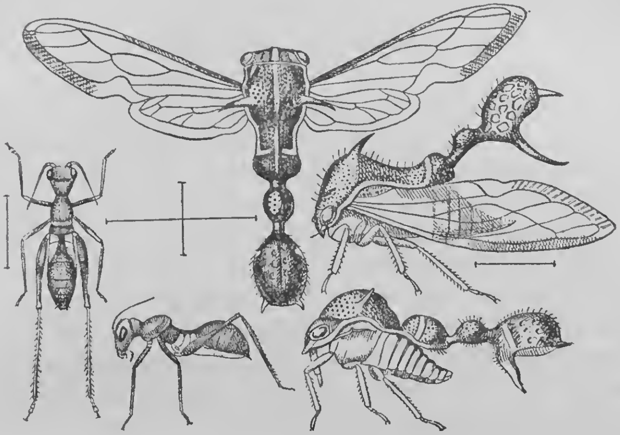


Fig. 5.

Fig. 5.—A Locustid from the Sudan, *Myrmecophana fallax* (Brunner), seen from above and from the left side. On this insect the appearance of an ant is represented in black pigment, all other parts being light in colour and presumably concealed. (From Brunner von Wattenwyl, Verhandl. d. k.-k. zool.-botan. Ges. in Wien, Bd. xxxiii. 1883, pl. xv. figs. 1 *a* & 1 *b*.)

Fig. 6.—A Central-American Membracid (Rhynchota Homoptera) in which the prothoracic shield resembles an ant. Thus the body of the insect which is not like an ant is concealed by an ant-like shield. The species is *Heteronotus trinodosus* as seen from above and the left side. The upper of the two figures seen from the side represents a female, the two other figures, males. (From W. W. Fowler, Biol. Centr.-Am., Rynch. Homopt. vol. ii. pl. 6. figs. 16, 16 A, & 17.)

Another and equally interesting method is adopted by certain tropical American Rhynchota Homoptera belonging to the family *Membracidæ*. In this remarkable group the dorsal region of the first thoracic segment (the pronotum) is of enormous size, extending upwards and backwards so as completely to cover the insect with the exception of the head, limbs, and wings. What natural selection effects in the general body-form of other insects, must here be effected, if it is to be of any value, in the shield which is seen, and not in the body which is concealed.

This change has been brought about, and certain species of the group have their un-ant-like bodies concealed under an ant-like shield. In other species the prothoracic shield is modified into a resemblance to other objects, such as seeds, thorns, &c.—an excellent example of the parallelism between mimetic and protective resemblance insisted on on page 565. The effects produced in the shield are at least as exact and detailed as those which in other cases are wrought in the form of the whole body; for, as Mr. W. F. H. Blandford has pointed out to me, a peculiar characteristic of certain tropical American ants (viz. the bead-like dilatation in the stalk of the abdomen) is reproduced in the shield of the membracid. This is well seen in *Heteronotus trinodosus* shown in fig. 6, copied from Canon W. W. Fowler's Monograph of the group in the 'Biologia Centrali-Americana.'

Finally, in the same group of *Membracidæ* we meet with another example which is also incapable of interpretation by any theory as yet brought forward except natural selection. An immature form of membracid, with the prothoracic shield not yet formed, found by W. L. Sclater in British Guiana, strongly resembles one of the leaf-carrying ants which are so common in that part of the world; but the resemblance includes the leaf as well as

Fig. 7.

Fig. 7.—About three times the natural size. On the right is represented an immature Membracid (Rhynchota Homoptera) from British Guiana, which resembles an ant together with the leaf it is carrying. The latter is shown on the left, and represents the species *Œcodoma cephalotes* from the same locality. (From Poulton, Proc. Zool. Soc. 1891, pl. xxxvi. fig. 2.)

the ant! The dorsal region of the membracid is flat and compressed, so that it is as thin as a leaf; its border (the dorsal surface, which formed a sharp edge) is jagged like a gnawed leaf, and during life it was green in colour. Beneath this leaf-like

expanse the brown head and legs of the insect were visible just as, in the case of the ant, they appear beneath the piece of leaf which is carried vertically between the mandibles and thrown over the back. This example was described by the present writer in Proc. Zool. Soc. 1891, p. 462. The appearance of the membracid and leaf-carrying ant is seen in fig. 7, which is reproduced from the paper just mentioned. It is possible that certain species of the Orthopterous genus *Tettix* (*Acridiidæ*) also resemble ants carrying leaves.

It would of course be ridiculous to ascribe this last resemblance to any direct external forces connected with locality, or to any internal forces, independently producing a like result, and, as the species was in an immature condition, it is equally impossible to invoke the aid of sexual selection.

Natural selection remains as the only feasible interpretation.

Even more striking than this remarkable example is the contemplation of all these various methods and their relation to each other. The means by which the resemblance to ants are brought about are diverse, the end—the resemblance itself—is uniform. Furthermore, the likeness is almost always detailed and remarkable, however it is attained, while the methods made use of differ absolutely. Such a result, it would seem, is the most complete proof of the operation of natural selection that can be attained, short of the actual demonstration of its action by observation and statistics. If this argument be confirmed by a study and comparison of the foregoing figs. 1 to 7, I venture to think that it will meet with general acceptance.

When one insect resembles an ant by the superficial alteration of its whole body-form, another by the modification of a shield-like structure which conceals its unaltered body, another by having the shape of an ant painted, as it were, in black pigment upon its body while all other parts are concealed; another by a further modification of its body, so that it represents not an ant only, but the object which the ant is almost always carrying,—when the effect of all these results is heightened by appropriate habits and movements, we are compelled to believe that there is something advantageous in the resemblance to an ant, and that natural selection has been at work. The phenomena do not merely disprove all other suggested causes of change, but they constitute the most powerful indirect proof of the operation of natural selection.

(12) *The Resemblances within the Limits of the Order are also produced in the most Diverse Ways.*

Illogical as I believe the position to be, it is quite possible that many observers may concede the force of the argument concluded above, and yet continue to hold that the resemblances within the Order are produced by external or perhaps by internal causes. It can however be shown that the same condition is true in the more restricted group as was found to apply to the wider. Even within the Order itself resemblances are produced in very diverse ways, although minute examination is sometimes necessary before the essential difference which separates them can be revealed.

Certain Longicorn beetles resemble weevils, the *Curculionidæ* being, so it is believed, specially defended by their extremely hard chitinous covering. The weevils closely resembled by such Longicorns as *Doliops curculionoides* and *D. geometrica* have short antennæ ending in a knob. The antennæ of the *Doliops* are nearly three times as long; the resemblance to the weevil being produced by a dilatation of the third joint, which represents the knob, while all the joints beyond are of such excessive fineness that they are almost invisible. The strong resemblance of the Longicorn *Estigmenida variabilis* to *Estigmena chinensis*, belonging to the *Hispidæ* (Phytophaga), is brought about in a similar manner, as was pointed out by C. J. Gahan. In this case about one third of the length of the Longicorn's antenna is concealed by its extreme fineness, while the apparent terminal thickening is produced by hairs at the end of the thicker section.

In these examples, kindly shown me by Mr. Gahan, neither the theory of external nor that of internal causes is of any avail. It is impossible to believe that the resemblance is a direct effect of climatic or other forces connected with locality, when the results are in reality so utterly different and yet superficially so entirely alike. The fact which requires explanation is the extraordinary likeness in spite of the essential difference, and this, when it is repeated again and again, cannot be interpreted by any theory unless based upon the principle of selection.

Many other examples of the same kind could easily be brought forward: in fact, it may be admitted as a general principle that in protective mimicry and common warning colours

the resemblance is *never* attained by precisely similar methods, and generally by methods which are extremely unlike. I propose, in concluding this Section, to discuss a few examples from the Lepidoptera, inasmuch as the resemblances in question have been chiefly studied in this group, and because an explanation based on the theory of external or on that of internal causes has been sought more often and pressed more strongly in the case of the Lepidoptera than in that of any other Order.

The *Pierinæ* are specially liable to take on these resemblances. In tropical America they chiefly resemble the *Ithomiinæ*, *Heliconinæ*, and *Papilioninæ*, affording some of the best and earliest recorded examples of mimicry (although Dr. F. A. Dixey has now shown that they are more probably to be interpreted as common warning colours). The chemical nature of the wing-pigments of the *Pierinæ* has recently formed the subject of an interesting paper by F. Gowland Hopkins (Proc. Roy. Soc. 1894, p. 5, and Phil. Trans. 1895, B. p. 661). The author shows that the white pigment so common in the group is an impure uric acid probably uncombined, that the yellow and orange pigment is a derivative of uric acid to which he gives the name "lepidotic acid," while a much rarer red pigment, less fully investigated, is probably of a closely similar constitution. These three pigments, with black, which is apparently intimately associated with the cuticle of the scales, with a pigment placed between the two laminæ of the wing and with superadded optical effects due to structure, account for the whole of the colouring of Pierine butterflies. No pigment of similar constitution to the Pierine white, yellow, and red, was found by Mr. Hopkins in any other butterfly—not even in the allied *Papilioninæ*. The Pierine butterflies which resemble the *Ithomiinæ* or other butterflies were found by Mr. Hopkins to achieve this end, not by gaining the true pigments of their models, but by means of the characteristic Pierine pigments. The bands of warm red-brown, the spots of white and yellow, which so closely resemble the same tints in the *Ithomiinæ*, are in reality caused by pigments of an entirely different nature—the resemblance, even between the pigments themselves, is wholly superficial.

The argument that the resemblances we are discussing are due to the common result of common forces, is simply an improbable assumption. It has been proved again and again

that the results are not common, the resemblance merely deceptive. And now this has even been shown for the colours themselves, in some of the best known and most striking examples of mimicry.

The last example of similarity in appearance produced through diversity of method is one which occurred to me a few years ago when lecturing on mimicry in the Hope Department at Oxford. It was worked out in detail during the summer of 1897, and the general results were communicated to Section D of the British Association at Toronto, on Monday, August 23rd, 1897. A brief abstract is printed in the Report of the Meeting (pp. 692–694).

Although the Lepidoptera are characterized as an Order by the clothing of scales upon the wings, cases are very frequent in which this covering has been in part, or almost wholly, lost. By comparison with kindred unmodified forms, as well as by microscopic examination of the transparent areas themselves, it is possible to show that this loss is recent, and to trace the steps by which it has been reached from a condition in which normal scales were present.

In the very large convergent group of tropical American Lepidoptera, which has sprung up round the best known species of the Ithomiine genera *Methona* and *Thyridia*, transparency of a large part of the wings is a characteristic feature. Throughout the group the ground-colour of the wings is transparent, with a black border which generally passes inwards as two transverse bands in the fore wing, separating the transparent part into three areas, and as one band in the hind wing, separating it into two areas. The group consists of *Ithomiinæ* (*Neotropinæ*) of many genera, of *Danainæ*, of *Pierinæ*, and of moths of the genera *Anthomyza* and *Hyelosia*, belonging to the *Pericopidæ* (*Hypsidæ*), and the widely separated genus *Castnia* (*Castniidæ*).

Under the theory of external causes we should expect that the transparency would be attained in a similar manner throughout, by the reduction of scales to hairs, by the complete loss of scales, or by some other uniform method. Under the theory of natural selection we should expect that the methods would be different in the different groups. There are many ways in which transparency can be attained, and we should expect that one group would submit one set of variations making towards the resemblance, another a different set, to the operation of

natural selection. It will be shown below that this prediction is abundantly justified.

Although H. W. Bates did not know all the species we recognize now, he knew of all the chief sections of this group, and described them (figuring certain of the species) in his paper published in the Transactions of this Society for 1862. A representation of the group as he describes it is shown in Pl. **42**. fig. 1; but he also mentioned another set of rather smaller insects which is really continuous with the other group and should be considered with it. This included the Ithomiine species *Dircenna epidero*, *D. dero*, and *D. rhoeo*, and the moth *Hyelosia tiresia*.

Owing to the kindness of Mr. Godman, Mr. Salvin, and Mr. Herbert Druce, I am able to figure the group as it is now known with over thirty species (Pl. **42**. fig. 2). The simple combination of transparency and black which makes up the whole of the appearance of these species renders an uncoloured representation entirely sufficient. The strong general resemblance which runs through this large group is well seen in fig. 2, which is taken from a beautiful photograph of the actual insects made by Mr. Alfred Robinson, of the Oxford University Museum. The arrangement of the insects for the camera upon small pieces of cork glued on to a sheet of glass. was a work involving great care and skill, and in this, as in so many other sides of my work, I wish warmly to thank Mr. W. Holland, of the Hope Department, for his most efficient help and ready kindness.

Microscopic examination of the *Ithomiinæ* (*Neotropinæ*) showed that the scales on the wings are of two kinds, broad and narrow, which alternate more or less regularly. In the transparent parts both kinds of scale can still be detected, the narrow being frequently reduced to fine simple hairs, and, in the most extreme cases, the broad scales being reduced to **Y**-shaped hairs. The two commonest species of the whole group, probably forming the centre towards which the others have converged, are shown in Pl. **43**. fig. 1. These species, belonging to very different genera, afford a good example of the closeness of resemblance which may be attained by common warning colours. The two forms are constantly found intermixed in collections, and superficially are almost exactly alike. Nevertheless, a study of the transparent part of the wing under the microscope reveals the fact that the degeneration of the scales

has reached a very different level in the two species. In this, as in all other instances, the transparent patch at the apex of the left fore wing was selected for study and for photomicrography. Dr. Gustav Mann, of the Oxford University Physiological Laboratory, kindly assisted me in the difficult details of this latter work, and such success as I have been able to attain I owe mainly to him. Fig. 2 shows the structure of the transparent patch in *Methona confusa*; fig. 3 its structure in *Thyridia psidii*. In both the broad scales are reduced to small bifid structures, of a distinctly different form in the two species; while the narrow scales are reduced to long extremely fine hairs in the *Methona*, and to much broader ones in the *Thyridia*. In both the transition into the scales of the opaque part of the wing is well seen on the upper part of the figures. The comparison between the almost identical appearance of the two insects as shown in fig. 1, and their real differences which are seen to be very marked in figs. 2 and 3, affords another good example of the principle which has been already so abundantly illustrated—that when a close superficial resemblance has been attained no further similarity in the details of structure is produced. This is apparent enough even in these two genera belonging to the same sub-family. It is of course illustrated in a far more striking manner when the affinity is much more remote.

We now pass to the *Danainæ* which fall into the group. The *Danainæ* supply it with two species, both belonging to the genus *Ituna*, shown in Pl. **43**. fig. 4. The *Ithomiinæ* were formerly classed with the *Danainæ*, and in any case form the sub-family which stands next to them. But fig. 5 shows that transparency is attained in an entirely different manner, the scales being neither greatly reduced in size nor much altered in appearance. It is the great reduction in numbers which is here the cause of the transparency. The scales retain their dark pigment and produce the effect of a grey dusting over the transparent areas. The transition into the opaque black part of the wing is well seen on the upper part of the figure.

Finally, there is a single species belonging to the distant family *Papilionidæ* and sub-family *Pierinæ*—*Dismorphia orise*. This species is shown in Pl. **44**. fig. 1 together with *Methona confusa*. The upper two figures of the *Methona* and of the *Dismorphia* show a male and female of the type form of each

species, while the lowest figure shows a form which is found in Ecuador. In certain parts of Ecuador the black borders and bands of the *Methona* (recently distinguished as *M. psamathe*, Godm. & Salv.) are much narrower than in the type form, and it is seen that the *Dismorphia* from the same locality has followed in the same direction. This interesting parallelism was pointed out to me by Mr. Salvin, and is here illustrated from lithographs of specimens in the Godman-Salvin Collection. Fig. 2 shows that, in *Dismorphia*, the transparency is attained, unlike the *Ituna*, by a reduction in size of the scales; while, unlike the *Ithomiinæ*, the normal shape and outline are preserved, almost unchanged.

It is a little remarkable that in this large and dominant group no member of the *Heliconinæ* has yet been shown to find a place.

The moths which join the group are shown in Pl. **44**. fig. 3. I believe that all the convergent species of *Anthomyza* and *Castnia* are represented in the figure; these are, at any rate, all that are to be found in the collection of Mr. Herbert Druce and the Hope Collection. There are, however, other species of *Hyelosia* which I was unable to obtain at the time the photographs made use of in preparing these Plates were taken.

Microscopic examination proves that the moths become transparent in two ways, which differ entirely from each other, and from any of the methods already described in the butterflies. A representation of the scales of the transparent part of the Castnias is shown in Pl. **44**. fig. 6. The scales are not reduced in size, but they have lost their pigment and are transparent; they are furthermore set up on edge so that the light freely passes between them. The scales further from the opaque border of the transparent patches are much more upright than those at the margin which have been selected for figuring. The arrangement in *Hyelosia* is shown in fig. 5, and it is seen to be closely similar to that of *Castnia*, save that the scales are much reduced in number. The lithograph of the scales of *Anthomyza* (fig. 4) proves that the scales are normal in size and arrangement. They lie flat on the wing-membrane with the usual overlap, but are so transparent that the light freely passes through them. Although transparent, they retain a more or less faint yellow or greenish-yellow tinge, but this is also to be noticed in the transparent part of the wings of *Methona*, *Dismorphia*, &c.

The comparison of these details is almost a demonstration of the operation of natural selection. We cannot conceive of natural selection acting other than along some such lines as those which have here been shown to exist; for it is impossible to believe that very different species with very different natures would present anything but very different variations for its action. On the other hand, we cannot conceive of any theory, not dependent upon the principle of selection, which could produce such extraordinary superficial resemblances among numbers of species by methods which are entirely unlike in all their details.

13. *The supposed direct Effect of Local Forces implies the Hereditary Transmission of Acquired Characters.*

Finally, the hypothesis which is more commonly than any other substituted for natural selection, has the further disadvantage that it implies the unproved improbable hypothesis of the hereditary transmission of acquired characters.

A discussion of this latter hypothesis cannot be attempted here. It will be sufficient to observe that after years of search no particle of evidence in its favour, which can stand the test of examination, has been forthcoming.

14. General Conclusions: *Natural Selection as the Cause of Mimetic Resemblance and Common Warning Colours.*

I think it is not too much to claim that, even if the theories which have been proposed as substitutes for Natural Selection, have not been destroyed in single Sections of this memoir,—and I confidently believe that they have been thus destroyed over and over again,—their most convinced supporter will admit that they must yield to the accumulated pressure of all the arguments here brought forward.

The resemblances of mimicry and common warning colours have certain salient features in common, certain peculiarities which are apt to manifest themselves repeatedly; they also bear certain general relationships to other resemblances in organic nature. In this paper I have attempted to set down all the general statements which can be made as to the phenomena under discussion. These general statements represent an

enormous number of observed facts in all parts of the world. I believe that the generalizations will be admitted to be sound and to be well warranted by the facts. Under any theory which is not based upon selection, the whole of the facts on which the generalizations rest become mere coincidences and receive no explanation of any kind. Under natural selection this vast body of facts becomes at once intelligible. Here the accumulated facts of the most diverse kind, which receive an intelligible explanation by the theory in question, yield a firm support to the theory. There are many theories which are held upon indirect evidence of precisely the same nature. We believe in evolution, not because we see it taking place, but because of the immense number of observed facts which it renders intelligible.

In the case of natural selection in relation to mimicry and common warning colours it is to be confidently hoped that direct evidence may yet be added; indeed, a considerable amount is even now forthcoming. Prof. Lloyd Morgan's recent work upon the activities and instincts of young birds of many species ('Habit and Instinct,' London, 1896) proves that their education is actually of the kind which is presupposed in the theories of H. W. Bates and Fritz Müller. He shows that they have no instinctive knowledge of things which are good for food, but examine and test everything. On the other hand, they have very retentive memories, and retain a firm impression of the appearance of objects which have given them an unpleasant experience. Furthermore, there was evidence that they are influenced in their behaviour towards other objects resembling the one which has proved objectionable to them. As to the aggressive Hymenoptera, the evidence of their special methods of defence is obvious to everyone. With regard to specially protected groups of butterflies there is a large amount of evidence from observation and experiment, but more is to be desired. As this paper is going through the press I have received the last of Mr. Frank Finn's interesting and important set of papers on this question (Journal, Asiatic Society of Bengal, lxiv. pt. ii. 1895, p. 344; lxv. pt. ii. 1896, p. 42; lxvi. pt. ii. 1897, p. 528; lxvii. pt. ii. 1897, p. 614). After a long series of experiments begun and conducted with a perfectly open mind, upon Indian insect-eating vertebrates, Mr. Finn concludes in favour of the theories based upon natural selection in the following words:—

"I conclude from these experiments :—

"1. That there is a general appetite for butterflies among insectivorous birds, even though they are rarely seen when wild to attack them.

"2. That many, probably most species, dislike, if not intensely, at any rate in comparison with other butterflies, the 'warningly-coloured' *Danainæ*, *Acræa violæ*, *Delias eucharis*, and *Papilio aristolochiæ*, of these the last being the most distasteful, and the *Danainæ* the least so.

"3. That the mimics of these are at any rate relatively palatable, and that the mimicry is commonly effectual under natural conditions.

"4. That each bird has to separately acquire its experience, and well remembers what it has learned.

"That therefore on the whole, the theory of Wallace and Bates is supported by the facts detailed in this and my former papers, so far as they deal with Birds (and with the one Mammal used). Professor Poulton's suggestion that animals may be forced by hunger to eat unpalatable forms is also more than confirmed, as the unpalatable forms were commonly eaten without the stimulus of actual hunger—generally, also, I may add, without signs of dislike."

Mr. Finn concludes with some very valuable suggestions as to the conduct of future experiments.

The chief objection that has been raised against the theories of Bates and Fritz Müller, and which was often insisted on in the discussion at the Entomological Society, is the want of evidence that birds are in any important degree the enemies of butterflies. Many excellent observers have rarely seen butterflies attacked by birds. On the other hand, the Müllerian theory only presupposes that the young birds test the palatability of a few members of each convergent group in their locality and henceforward avoid all the members, so that the recent tendency to explain so many of these resemblances on Müllerian rather than on Batesian lines is in harmony with the conclusion that the members of such groups are not greatly attacked.

As regards butterflies which do not exhibit these resemblances, I may point out that it is impossible to exhaust the details of the struggle for existence even as regards a single species, in the intervals of the time devoted to collecting. Such an investigation would demand the whole time of a first-rate

observer, and, so far as I am aware, the inquiry has never been approached in so thorough a manner. Even if collectors would pay attention to the worst specimens instead of the best, some evidence of the nature and amount of attack would be forthcoming. During the visit of the British Association to Canada last year (1897) I made a point of capturing butterflies which had evidently been pecked by birds. In this way, although I did not witness a single attack, I obtained the proof that butterflies are not nearly so immune as has been asserted. On another occasion I hope to deal with this evidence in detail. Similar observations have been made by Fritz Müller.

The review of the whole subject during the past 36 years increases our confidence in the theories of Bates and Fritz Müller, while it disposes of all alternative hypotheses. Even more than this,—it will, I believe, be claimed by all who take a broad view over the whole field of evidence, that the explanation of these deeply interesting facts, which form so fascinating and important a department of natural history in the tropics, is one of the most notable triumphs ever won by the great theory of natural selection.

EXPLANATION OF THE PLATES.

Plate 40.

Certain aspects of Mimetic Resemblance in Lepidoptera.

Fig. 1. Natural size. This figure represents the appearance of the young larvæ of *Stauropus fagi* in the first stage, upon a twig of birch. The drawing was made from living specimens in the Hope Department at Oxford by P. J. Bayzand. The ant-like appearance is produced by the immensely elongated second and third pairs of thoracic legs, which are kept in a state of active movement upon the slightest disturbance. The caudal shield with its two processes resembles the head and antennæ of an ant. This figure should be studied in connexion with figures 1 to 7 in the text (Section 11), in which the resemblance to ants is shown to be brought about in many very different ways, thus supporting an interpretation based on the theory of natural selection.

Fig. 2. Natural size. A group of the young larvæ of *Endromis versicolor* upon a twig of birch. Drawn from life in the Hope Department by P. J. Bayzand. The larvæ are represented in the attitude they assume when disturbed, the anterior part of the body being thrown back and the orange-coloured thoracic legs exposed to view. In this position they strongly suggest the appearance of a group of young larvæ of

Tenthredinidæ, in which the *posterior* part of the body is raised on disturbance, while the orange ventral glands are everted and rendered conspicuous. The larvæ of *Endromis* afford a good example of mimetic resemblance almost entirely brought about by appropriate instincts (the gregarious instinct, the movements and attitudes assumed on disturbance). Thus the results are due to internal changes (in the nervous system) with only a minimum of superficial modification.

Fig. 3. Natural size. A group of larger larvæ of *Endromis versicolor*, also drawn upon birch by P. J. Bayzand. The figure shows that as the larvæ increase in size their instincts undergo appropriate changes leading them to form much smaller groups like the smaller groups of the more advanced larvæ of *Tenthredinidæ*. The attitude represented is that which follows disturbance.

Figs. 4–9 were drawn from specimens in the Hope Department, and are intended to show the retention of ancestral features upon parts which are normally concealed and the restriction of mimetic modification of colour and pattern to the parts which can be seen. They incidentally show examples of the more complete development of mimetic resemblance in the female sex.

Fig. 4. About $\frac{3}{5}$ natural size. The male of *Dismorphia praxinoe*, showing the manner in which the long-and-narrow-winged appearance of an Ithomiine is brought about in this broad-hind-winged butterfly. A comparison of the right and left sides of the figure clearly indicates the manner in which this appearance is produced by the excessive amount of overlap which occurs in the natural position of the wings (left side). Hence the greater part of the surface of the upper side of the hind wing and the under side of the fore wing is hidden in a natural position, and upon these concealed parts a large patch of the old Pierine white appearance is retained, seen, in the case of the hind wing, on the right side of the figure.

Fig. 5. About $\frac{3}{5}$ natural size. The male of *Dismorphia praxinoe*, showing the under side of the wings in the natural position (left side), and with the wings separated on the right side so as to expose that part of the under surface of the fore wing which is normally concealed. Here, too, a large white patch is to be seen.

Fig. 6. About $\frac{3}{5}$ natural size. The female of *Dismorphia praxinoe*, figured in the same manner as the male in fig. 4, and showing that the wings are really long and narrow with only the amount of overlap which is usual in butterflies. No white is to be seen upon the narrow band of the hind wing, which is concealed in the normal position.

Fig. 7. About $\frac{3}{5}$ natural size. The female of *Dismorphia praxinoe*, figured to show the under side of the wings similarly to that of the male in fig. 5. Here, too, it is seen that no white patch like that of the male is retained.

Fig. 8. About $\frac{3}{5}$ natural size. The male of *Dismorphia orise* represented in the same position as that of the male of *D. praxinoe* in fig. 4. Here, too, in this transparent, black-barred species, immensely modified by mimetic resemblance, the white patch is still retained (in the male), as

seen on the right side of the figure. The female of the species is shown in Group 1 on Plate **42** and two forms of it in fig. 1 on Plate **44**. The female of *D. orise* lacks, as do all the females of the genus, the chalky patches which are present in the males of many of the species.

Fig. 9. About $\frac{3}{5}$ natural size. The male of *Dismorphia orise* represented in the same position as that of the male of *D. praxinoe* in fig. 5, so as to show the under side of the wings. The white patch is distinctly seen on the normally concealed part of the fore wing (right side).

Plate **41.**

The diverse methods by which Mimetic Resemblance is attained, often in closely related species. I have been kindly permitted to make use of specimens in the Natural History Museum for obtaining figures 1, 2, 5 A, 5 B, and 5 C. The remaining figures represent specimens in the Hope Department.

Fig. 1. Natural size. A South-American Hemipterous insect belonging to the genus *Myocoris*, probably *M. braconiformis*. The usual appearance of a Hemipteron has been profoundly modified so as to produce a superficial resemblance to the Aculeate Hymenopteron shown in the next figure.

Fig. 2. Natural size. A South-American species of *Braconidæ*, probably belonging to the genus *Iphiaulax*, closely resembled by the bug shown in fig. 1. A large assemblage of tropical American insects probably converges round this type of appearance. Already many species of *Braconidæ* and of Hemiptera, together with two species of moths (*Syntomidæ*), can be recognized. So far, all the members of the assemblage belong to distasteful or specially defended groups, and probably supply an example of Common Warning Colours.

Figs. 3, 4, 5, 6, & 7 show the different methods by which the resemblance to stinging insects (Aculeate Hymenoptera) has been brought about in nearly related Longicorn beetles.

Fig. 3. Natural size. A Mediterranean species of *Clytinæ*, *Plagionotus scalaris*; one of many species of the group in which the resemblance to a wasp is produced by the black and yellow bands on the closed elytra, as well as by the slender yellow legs and active movements, &c. In this case the functional wings are concealed, and there is nothing to suggest the wings of the model. In spite of this shortcoming the living species of this group are very wasp-like. The resemblance is carried to a still higher level by very different means in allied tribes of Longicorns.

Fig. 4. Natural size. A species of *Callichrominæ* from the Oriental Region, viz. *Nothopeus hemipterus*. In this beetle the general resemblance to a dark-coloured slender wasp is carried much further than that of *Plagionotus* (fig. 3) to a black and yellow wasp such as the species of the genus *Vespa*. Furthermore the likeness is heightened by the size and conspicuousness of the hind wings of the beetle, which are

freely exposed at rest as well as in flight. This is brought about by a reduction of the elytra to small oval scales. Hence the resemblance which is so largely due to the colouring of these parts in *Plagionotus* is here in an allied form due to the appearance of parts which are concealed, except during flight, in the former. It is also to be noted that the exposed under wings have the dark tint, which is so common in the species of stinging Hymenoptera, and that such exposure of the functional wings is very unusual in Coleoptera and is almost, if not entirely, confined to the species in which their display is made part of a mimetic resemblance.

Fig. 5. Natural size. An Australian species of *Esthesinæ*, *Esthesis ferrugineus.* In this beetle the elytra are reduced to squarish scales and the under wings freely exposed at rest. The bold and characteristic colouring is found in many Australian insects of which three other examples are figured here.

Fig. 5 A. Natural size. An Australian fly, a species of *Dasypogon* (*Asilidæ*), with the same type of colour and pattern as that of the last and the two succeeding figures. This Dipterous insect resembles the wasp represented in fig. 5 B with especial closeness.

Fig. 5 B. Natural size. An Australian wasp, *Abispa australis* (*Eumenidæ*), which is in all probability the central type of this characteristic Australian group.

Fig. 5 C. Natural size. Another Australian wasp, *Eumenes Latreillei* (*Eumenidæ*), which falls into this group. Other species of Australian wasps are also included, and probably additional insects of other Orders from the same region will be found to possess a similar type of colouring.

Fig. 6. Natural size. A Brazilian species of *Rhinotraginæ*, *Isthmiade braconoides*, in which the very slender form strongly suggests the appearance of a Hymenopterous insect. The colouring and pattern of the wings is very rare in beetles, and is in all probability mimetic of some stinging insect from the same part of the world. The elytra are here reduced to linear vestiges somewhat broadened at their bases; they leave the under wings freely exposed.

Fig. 7. Natural size. A species of *Hephæstion* sp. (*Necydalinæ*) from Chili. The appearance is extremely wasp-like, and is brought about by a reduction of the elytra very similar to that indicated in the last figure. The under wings are dark like those of so many wasps, and the whole appearance most suggestive of a stinging insect and unlike that of a beetle.

Thus in this Plate five species of nearly related Longicorn beetles are represented. The appearance of a wasp is chiefly suggested by the colouring of the fully developed elytra of one species (fig. 3), by the reduction of the elytra and form and colour of the parts thus displayed, in all the rest (figs. 4, 5, 6, & 7). Furthermore the elytra are reduced to oval remnants in one (fig. 4), squarish in another (fig. 5), and linear (with broader bases) in the remaining two (figs. 6 & 7). Stout-bodied black and yellow wasps, such as those of the genus *Vespa* (or the *Abispa* shown in fig. 5 B), are resembled by two (figs. 3 & 5),

while the remaining species (figs. 4, 6, & 7) are mimetic of slender Aculeata with opaque, iridescent, or even particoloured wings.

Hence in this group of allied species of beetles there is great diversity in the methods by which the mimetic resemblance is attained and in the form of the model which is imitated. One thing is common to the whole, viz. the production of a strong superficial likeness to a stinging insect. Such community of end through diversity of means strongly supports an interpretation based on the theory of natural selection.

Plate 42.

The resemblances between the members of a large and characteristic group of transparent and black-barred South-American Lepidoptera.

Fig. 1. About ⅓ natural size. The group as described by Bates in 1862 (Trans. Linn. Soc. xxiii. pp. 495–566). The names of the species are engraved on the Plate. The species belong to very different divisions, families, and sub-families of Lepidoptera. Thus the *Ithomiinæ* are represented by two species in different genera, the *Danainæ* by two species, the *Pierinæ* by one, while the moths belong to the very different families of the *Castniidæ* and *Pericopidæ*, the latter including *Anthomyza*. Bates also described a group of smaller Ithomiine species, *Dircenna epidero*, *D. dero*, and *D. rhoeo*, as well as another smaller moth (*Hyelosia tiresia*) belonging to the *Pericopidæ*. Of these he made a second group, but they are in reality continuous with that shown in fig. 1, having a very similar arrangement of black bars and border on their transparent wings. The group has in all probability converged around the two common and widespread Ithomiine species of the genera *Methona* and *Thyridia*. All members of the group, including these latter, are to be looked upon as primitively opaque-winged. If selection has been at work in the alteration of the scales so as to render them transparent, we should expect that this common end would have been reached by very different methods in the case of species belonging to such widely separated divisions.

Fig. 2. About ¼ natural size. By the kindness of Messrs. Godman and Salvin I have been enabled to figure, from their great collection, all the species of butterflies which are now known to fall into the two groups described by Bates 37 years ago. The *Danainæ* and *Pierinæ* remain unchanged, but the *Ithomiinæ* have been immensely enlarged, containing 20 species in seven genera. Many of these are extremely rare, and so complete a set could not have been got together from any other collection. I also owe to their kindness the loan of butterflies shown in fig. 1 and of some in Plates **43** and **44**.

Many species of *Castniidæ* and of *Pericopidæ* have now been added to the group. Those which are here shown, as well as in fig. 1, and those in Plate **44** were in part obtained from the Hope Collection and in part from the very fine collection of Mr. Herbert Druce, who kindly lent them for the purpose of this memoir. The set is probably complete, or nearly so, except in the genus *Hyelosia*.

PLATE **43**.

The divergent methods by which the transparency—an important element in the resemblance between the members of the group shown on Plate **42**—has been attained in *Ithomiinæ* and *Danainæ*.

Fig. 1. About $\frac{2}{3}$ natural size. The two central Ithomiine species round which the group has in all probability converged. The extraordinarily close resemblance between these butterflies belonging to entirely different genera is a very fine example of common warning colours. The next two figures will show that so close a resemblance is quite superficial; for there is a very wide difference between the shapes of the scales on the transparent areas of the two species.

Fig. 2. × about 15. In this and all the other figures of scales on Plates **43** and **44**, a portion of the transparent patch at the apex of the left fore wing has been figured, including a small part of the opaque margin, so as to show the manner in which the transition is effected. The scales of butterflies and moths overlap from the base of the wing towards its apex, and therefore in the arrangement here adopted the uppermost part of each figure lies in the direction of the apex of the wing. On this Plate a portion of the opaque border on the outer side of the transparent patch, viz. towards the apex, is represented, and is therefore uppermost in each of the three figures. In Plate **44** a portion of the border towards the base has been drawn, and therefore occupies the lowest part of each of the four figures.

The magnification was as nearly as possible equal in all the seven figures representing the scales. All the specimens which were thus drawn belong to the Hope Department. Fig. 2 represents the scales of *Methona confusa*, and it is seen in the upper part of the circle that the opaque surface of the wing is covered with broad forked scales regularly alternating with long and narrow ones. On the transparent part the latter are reduced to extremely fine hairs, the former to minute bifid structures.

Fig. 3. ×about 15. The scales of *Thyridia psidii*. The scales of the border in this species are seen to differ somewhat in form from those of *Methona*, while the difference on the transparent part of the wing is very marked, the narrow scales being far broader and the bifid ones of a different shape. The method by which transparency is attained is however the same although the details differ. A method similar in all essential respects was found in all the Ithomiine species shown on Plate **42**. fig. 2. In certain species, however, the process was carried further: thus in *Dircenna* the broader scales were reduced to **Y**-shaped hairs, as well as the others to simple hairs.

Fig. 4. About $\frac{1}{2}$ natural size. The two species of the Danaine genus *Ituna*, *I. ilione* and *I. phenarete*, which enter the group. The *Ithomiinæ* were formerly classed with the *Danainæ*, but the important differences between them are now generally recognized as justifying their separation into two distinct sub-families.

Fig. 5. ×about 15. The method by which transparency is attained in the Danaine genus *Ituna* is seen to be entirely different from that followed

in the *Ithomiinæ* (figs. 2 & 3). The scales on the opaque border of the transparent area are almost uniform in appearance, forming the sharpest contrast with those of the *Ithomiinæ*. In the transparent part the individual scales are but little changed in appearance or size, but they are immensely reduced in number, so that the light freely passes between them. The scales which remain merely cause the appearance of a grey dusting over the transparent surface. *Ituna ilione* was drawn for this figure, the other species, *I. phenarete*, only differing in this respect by its even more complete transparency in consequence of a still greater suppression of the scales.

Thus the course of development leading to superficial resemblance has been entirely different in the species of these two sub-families—the *Ithomiinæ* and *Danainæ*.

Plate 44.

Further divergent methods by which the transparency necessary for the likeness has been attained in other members of the group shown on Plate 42, viz. in the *Pierinæ*, and among moths in the *Pericopidæ* and *Castniidæ*.

Fig. 1. About ½ natural size. On the right side is seen the single Pierine species which enters into this group, viz. *Dismorphia orise*. The two upper figures are male and female of the type form found in many parts of tropical South America. Opposite them on the left is a male and female of the type form of *Methona confusa*. The specimen represented in the lowest position on each side is a form which occurs in Ecuador, in which the transparency is increased at the expense of the black bars and border. It is very interesting that this form of *Methona* should thus have been followed by the Pierine butterfly in the same area. The former has recently been distinguished as *Methona psamathe* (Godm. & Salv.).

Fig. 2. ×about 15. The scales on the transparent part of the left apical patch on the fore wing of *Dismorphia orise*, the opaque border being represented at the lower part of the circle. In this case a third method has been adopted. In *Ithomiinæ* the widely different scales were reduced in size and simplified in shape: in *Danainæ* the uniform scales were reduced in numbers rather than in size: while here in the *Pierinæ* they have been reduced in size rather than in numbers, but remain almost unchanged in shape. The amount of reduction in size in this species is better seen by comparison with other parts of the opaque surface upon which the scales are far larger than those of the border which are shown in this figure.

Fig. 3. About ½ natural size. A set of day-flying tropical South-American moths which fall into this group. The two left-hand rows are five species of the genus *Anthomyza*. The upper pair are *A. brotes* (Druce), male left, female right; the next *A. Buckleyi* (Druce), male left, female right; the next *A. Swainsoni* (Druce), both female; the last pair being *A. praxilla* (Druce) on the left, and *A. tiresia* (Cr.) on the right. The two lowest moths of the figure are *Hyelosia tiresia* (Cr.).

These and the species of *Anthomyza* belong to the *Pericopidæ* (*Hypsidæ*). The row of moths on the right hand are widely separated from the others, being the species of *Castniidæ* which belong to the group. The uppermost moth is *Castnia linus* (Cr.), the next *C. dodona* (Druce), the next *C. heliconioides* (Herr.-Sch.), and the lowest *C. micha* (Druce).

Fig. 4. ×about 15. The method by which transparency has been gained in the genus *Anthomyza*. Although *A. Buckleyi* has been drawn for this figure, the method is identical in all the species. The scales lie flat on the wing with an entirely normal arrangement and overlap. Their size and shape are but little altered, but the scales themselves become quite transparent (compare the border scales seen in the lower part of the circle). There is generally a little yellowish or faintly greenish-yellow pigment retained, giving a tint which closely resembles that of *Methona* and other members of the group, none of which are entirely colourless. This method contrasts in a most interesting manner with all the others made use of in attaining transparency as an element in superficial resemblance.

Fig. 5. ×about15. The scales on the transparent part of the wing of *Hyelosia tiresia*, part of the border being shown on the lower part of the figure. The scales are greatly reduced in number, they become transparent and are set in a far more upright position on the wing-membrane. In these ways they interfere but little with the passage of light. The wide contrast with *Anthomyza*, belonging to the same family, is of high interest.

Fig. 6. ×about 15. The method adopted by the species of *Castnia* has much resemblance to that of *Hyelosia*, although the forms are so distantly related. All the species examined have the same method, the scales of *C. linus* being actually drawn for the figure. The scales are not reduced in size and but little, if at all, in number, The shape is somewhat simplified, and the pigment is lost. At the same time the scales are set much more steeply on the wing-membrane, and the light freely passes between their rows. This is seen to be the case in fig. 6, but further from the border of the transparent patch they become practically upright. Even where the slope becomes less the light still passes through (although less perfectly), because of the transparency of the scales.

Hence in this large group of superficially similar South-American Lepidoptera figured and studied in some of its minute details in Plates **42, 43,** and **44,** the transparency which is essential to mutual resemblance has been produced by widely different methods:—the same end, viz., the production of a close superficial likeness, has been reached from very divergent paths. Such a result, while harmonizing with an explanation based on the principle of selection, and especially on the theory of natural selection, is quite inexplicable on any other hypothesis which has as yet been suggested.

Westwood Bequest

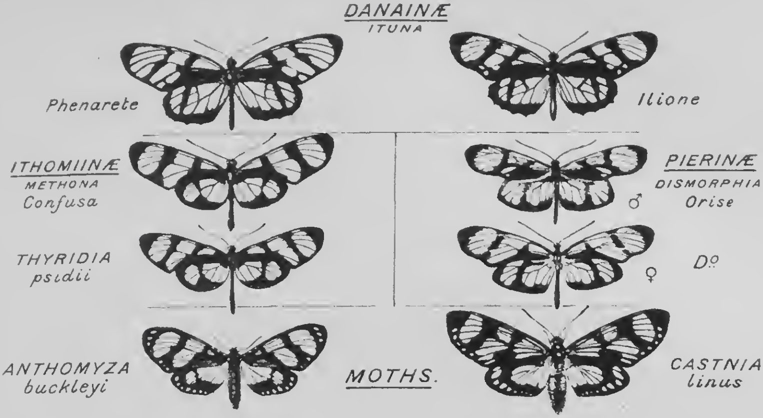
Edwin Wilson, Cambridge

Mimetic Resemblances in Lepidoptera.

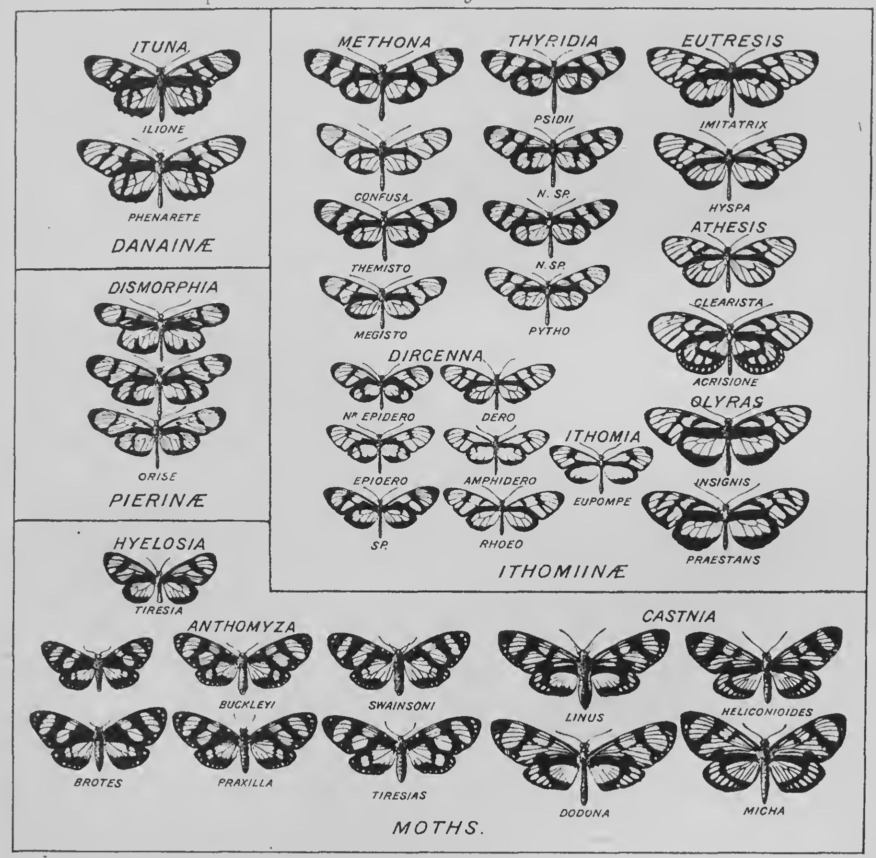
WESTWOOD BEQUEST

EDWIN WILSON, CAMBRIDGE

Mimetic Resemblances in Insects
other than Lepidoptera



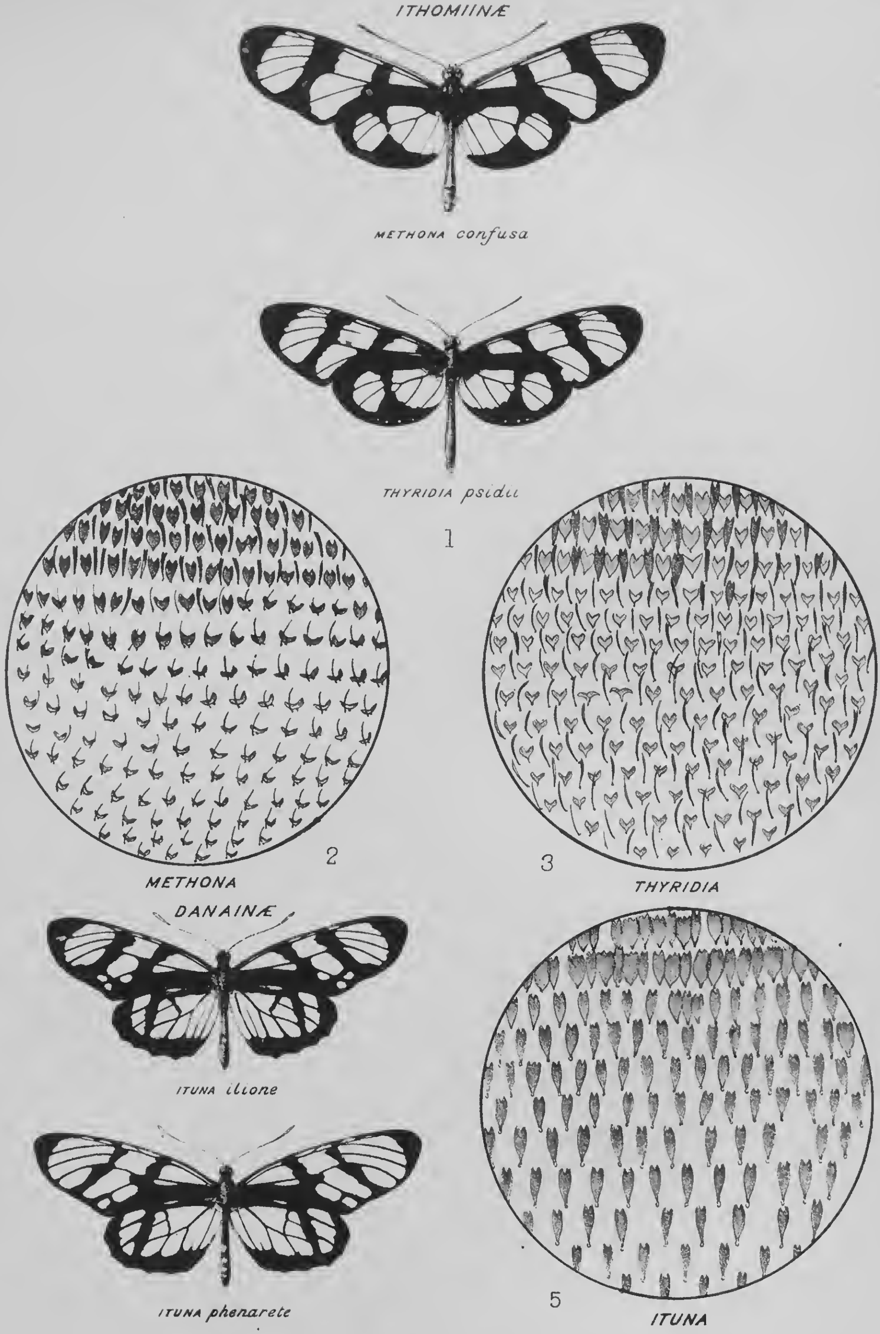
1 Group as described by H W Bates in 1861.



2. Group as known in 1897.

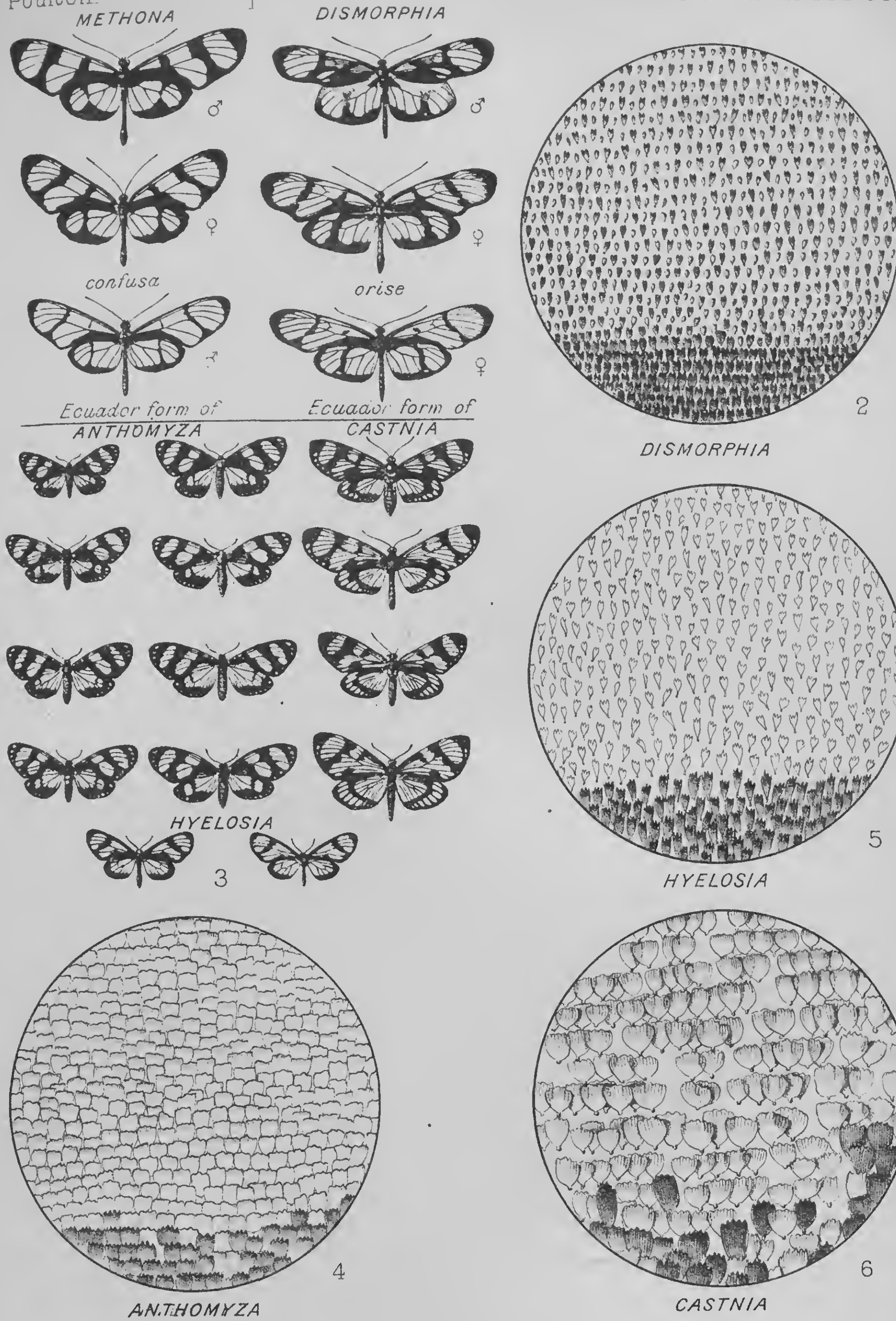
EDWIN WILSON, CAMBRIDGE.

RESEMBLANCES IN TROPICAL AMERICAN LEPIDOPTERA.



EDWIN WILSON, CAMBRIDGE.

Resemblances in Ithomiinæ and Danainæ.



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RESEMBLANCES IN PIERINÆ AND MOTHS.

An Experimental Enquiry into the Struggle for Existence in Certain Common Insects. By EDWARD B. POULTON, *M.A., F.R.S., Hope Professor of Zoology, Oxford, and* CORA B. SANDERS.

[An abstract of a paper read before Section D of the British Association at Bristol, on Monday, September 13, 1898. Reprinted from the 'Report' (pp. 906–909) of the meeting.]

Many Lepidoptera have been proved to possess the power of adjusting the larval or pupal colours to those of the immediate surroundings. This power can only be exercised once in the case of the pupa (viz. at the end of larval life), and rarely, if ever, more than once or twice in the case of the larva. Many naturalists consider that the power is protective, and has been produced by the operation of natural selection. Others have doubted this conclusion, and W. Bateson[1] has attempted to cut away the foundation of such an interpretation as regards the pupa of *Vanessa urticæ* by arguing that there is no struggle for existence during this brief stage. This argument was opposed, and the lines of an experimental enquiry were suggested in the same year by one of us.[2] In the discussion which followed a paper on mimicry, read before the Linnean Society on March 17, 1898,[3] it was strongly urged, especially by Professor Weldon, that such an experimental enquiry should be conducted. Our present work is the outcome of that discussion, and we desire to express our thanks to the Government Grant Committee of the Royal Society for assistance in carrying on the investigation.

We determined to concentrate our attention on the pupæ of certain butterflies, this stage being especially suitable because the chrysalis is motionless, and, therefore, remains in any position in which it has been fixed until it is seized by an enemy or emerges as an imago. Our object was to decide:—(1) whether there is a struggle for existence during the pupal stage; (2) whether the struggle, if it takes place, is decided by the conspicuousness of the pupa.

The enquiry was almost confined to the pupa of *Vanessa urticæ*, which ranges from a brilliant golden appearance through increasingly dark varieties up to black. Seven degrees of colour variation were distinguished, as in the researches into the sensitiveness of this pupa to its environment.[4] Captured larvæ were placed in boxes lined with gilt, black, and yellow paper, &c., so as to produce pupæ with different degrees of colour, the aim being to obtain the most contrasted results. The pupæ were then fixed to the surfaces upon which they are known to occur in nature, and others upon which they may be supposed to occur—viz. the food plant (nettle), tree trunks, fences, stone walls, and rocks—while a few were placed on the ground. They were attached by small nails driven through the silken web, in which the caudal hooks were entangled, or (in the case of the food plant) by sewing the web on to the leaves or stem with green silk; in other cases the hooks were entangled in the outer part of a little plug of cotton wool, which was forced into a crack in bark, wood, or stone. Careful notes were taken of the degree of colour, method, and height of attachment, character of surface, and the date of all visits until the pupa either disappeared, emerged, or died. With very few exceptions, visits were made every twenty-four hours, and in many cases at much shorter intervals. Over 600 pupæ of this species were thus fixed, and of these about 550 disappeared or emerged. The experiments were conducted in three different

[1] *Trans. Ent. Soc.* Lond. 1892, pp. 212, 213.

[2] Poulton, *Trans. Ent. Soc.* Lond. 1892, pp. 471–477.

[3] Poulton, *Natural Selection the Cause of Mimetic Resemblance and Common Warning Colours.* Not yet published.

[4] Poulton, *Phil. Trans. Roy. Soc.*, vol. clxxviii. (1887), B. p. 320; and *Trans. Ent. Soc.* Lond. 1892, p. 362.

localities—Oxford, Switzerland, and the Isle of Wight—with very divergent results, as will be seen from the following table:—

Surfaces to which Pupæ were fixed	Oxford		Mürren		Visp		Isle of Wight: St. Helen's	
	June 25–July 23		July 11–July 17		July 21–July 25		Aug. 2–Sept. 3	
	Taken	Emerged	Taken	Left	Taken	Left	Taken	Emerged
Bark . . .	29	0	—	—	5	16	135	84
Fences . . .	4	0	0	18	—	—	90	8
Rock . . .	—	—	4	31	7	25	—	—
Walls . . .	4	0	—	—	1	5	14	12
Nettle . .	7	4	—	—	—	—	20	15
Ground . . .	11	0	—	—	—	—	—	—
Totals . . .	55	4	4	49	13	36	259	119

It should be noted that the Swiss pupæ which were not taken are marked 'left' because many of them did not emerge, but were removed at the close of the visit and used over again. The results thus tabulated leave no doubt about the existence of an immense amount of extermination at Oxford, and, although much less, a large amount in the Isle of Wight, while there was comparative immunity in the two Swiss localities. This strong contrast is probably to be explained by the scarcity of small birds in the latter, and their abundance in England, and especially in Oxford, together with the fact that the Oxford experiments were conducted earlier in the year Other considerations point to the same conclusion viz. that birds are the enemies in question;—the inaccessible position of the pupæ, which were nearly always fixed at a height of about four feet from the ground; the fact that the hard caudal extremity was frequently left attached after the pupa itself had been taken; the excessive variation in mortality in neighbouring localities, corresponding to well-known facts in the distribution of birds. A watch was kept in localities where the pupæ were known to disappear rapidly, and, in a single instance, a great tit was seen to creep over the bark of a tree, from which the pupa was then found to have gone.

So far as the observations extended, we inferred that the comparative freedom of the Swiss pupæ from the attacks of Vertebrate enemies is compensated by the far greater destruction of the larvæ by insect parasites. It is probable that the birds which attack the English pupæ benefit the larvæ by keeping down the number of parasites.

In the course of the enquiry the possibility was suggested that perhaps the birds actually see the pupæ being suspended, and afterwards search the spot. A large number of pupæ were, therefore, fixed at night by the light of a lantern, but, so far as we can judge from general impressions (the analysis of the results being unfinished), no difference was caused. It was also thought that, when several pupæ were suspended in close proximity, the birds, after finding one or more, might search the neighbourhood with especial keenness, so that the chances of successful concealment would be smaller than those of isolated pupæ. In order to test this suggestion, a number of pupæ were scattered over a large area, successive individuals being separated by a distance of about 100 yards or more. Here, too, our present impression is that little, if any, difference was produced. Both these modifications of the usual conditions of experiment were made in the Isle of Wight.

The question whether there is a struggle for existence during the pupal period of *Vanessa urticæ* is answered with certainty in the affirmative as regards those localities where small birds are abundant. In such places it is now proved that there is a tremendous struggle with an immense mortality, in spite of the brevity of the pupal stage (from ten days to three weeks in length).

The attempt was also made to answer the second question whether the struggle is decided by the conspicuousness of the pupa. First, as to conspicuousness in form, pupæ were fixed to surfaces which unequally concealed them; thus the rough surfaces of stone and bark (rough-barked trees being almost invariably selected), and the shelter afforded by overhanging leaves of nettle, concealed their rough angular forms far more than the comparatively smooth surface of fences. Looking at the table on page 907, it is seen that at Oxford butterflies only emerged from pupæ fixed to nettles, while in the Isle of Wight the mortality on fences (90 taken to 8 emerged), was enormously greater than on bark (135 to 84), walls (14 to 12), and nettle (20 to 15). When therefore the pupa is suspended from a surface against which it stands out conspicuously, it is in far greater danger than when it is fixed to one upon which it is concealed. This result is inexplicable, except on the theory that the sense of sight is important to enemies in the discovery of the pupæ.

Secondly, as to conspicuousness in colour. In Nature the golden forms of the pupa of this species are produced upon nettle, the darker forms on walls, rocks, fences, and probably bark; furthermore the darkest varieties are produced on the darkest surfaces. In fixing the pupæ, part were distributed as they are in Nature, while part were given a reverse arrangement—dark forms being fixed to nettle, and golden forms to black fences and dark surfaces of bark, &c. Some of the experiments gave extremely positive results, in that the mortality among the latter pupæ was far higher than among the former; other experiments were negative. Until the whole of the experiments have been analysed in far more detail than has as yet been possible, we cannot make any statement as to the general bearing of the inquiry upon the danger or otherwise of conspicuousness in colour, although the danger of conspicuousness of form has been shown to be conclusively proved.

It may be supposed that the experiments were vitiated by the accidental loss of the pupæ. Many considerations, however, indicate that no serious error has been introduced in this way. In the absence of enemies, in Switzerland, the pupæ remained suspended until they emerged or until we removed them, and this was also the case in the places of small mortality in the Isle of Wight; in many places the ground was bare, and a fallen pupa (always searched for) would have been easily seen; the hard caudal extremity was frequently left fixed to the supporting surface; the different results obtained on fences and on bark, &c., are manifestly inexplicable on this ground, the means of fixation being the same. The act of emergence was obviously a much severer test of our method of suspension than that supplied by the motionless pupa; and yet in a large proportion of cases the empty pupal shell was found hanging to the support, and thus remained for days, in spite of the fact that its lightness enabled each breath of wind to blow it about.

In future inquiries we trust that a pupa with a wider colour variation than *V. urticæ* may be available. All attempts to obtain the larva of *Vanessa io* were unsuccessful, but next year we hope to get it and test the bright green and dark forms which its pupa assumes. Other excellent examples would be the bright green, bone-coloured, and dark forms of the pupæ of *Pieris napi* and *P. rapæ*, which have the further advantage of being available for experiment during the winter. Through the kindness of Mr. F. Merrifield we shall be able to carry on the inquiry with these latter and some other species during the winter of 1898–9, when we hope again to appeal to the kindness of the President and Fellows of Magdalen College for the opportunity of continuing the investigation begun during the past summer in the College grounds.

We also desire to acknowledge the kind assistance we have received from Miss Drummond and Miss Sidgwick in taking notes of the Oxford pupæ during our absence in Switzerland, and from Miss Notley for much kind help in the Isle of Wight. Professor H. F. Osborn, Professor F. O. Bower, and Mr. Arthur J. Evans also witnessed the experiments in the Isle of Wight, and offered valuable suggestions and criticism.

The investigation, of which this is a brief epitome, was manifestly a preliminary inquiry: it has nevertheless yielded far more definite results than we ventured to hope for when we undertook it.

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2. *Observations on Mimicry in South African Insects.* *By* Guy A. K. Marshall.

[Arranged and Communicated by Edward B. Poulton, M.A., F.R.S. Fellow of Jesus College, Oxford, and Hope Professor of Zoology in the University.]

The following paper is an abstract of the results obtained by Mr. Guy A. K. Marshall in South Africa. When no locality is mentioned it is to be understood that the observation was made at Salisbury, Mashonaland (5,000 feet). The observations here briefly recorded have added in a most important manner to our knowledge of the natural history (bionomics) of South African insects, a subject of which the foundations were laid by Roland Trimen. Groups of mimetic Lepidoptera captured on the same day as their models have been obtained both from Natal and Mashonaland (Salisbury), thus demonstrating more fully than has been done hitherto the fact that model and mimic fly at the same time as well as in the same place. The groups bring out the extraordinary power of Danaine butterflies in, so to speak, moulding the species of other sub-families into a superficial likeness to themselves. There are only four or five species of *Danainæ* in the region under consideration, and each one of them is the centre of a group of forms superficially similar, but remote in affinity. The abundant and widespread *Limnas chrysippus* was largely resembled both in Natal and Mashonaland. In experiments conducted upon insect-eating animals, this butterfly appeared to be less unpalatable than the *Acræa* (*A. encedon*) which resembles it. The explanation may be found in the far wider range of the Danaine model, which would render it familiar to enemies passing from an area in which the *Acræa* does not, to one in which it does exist.

In the case of two forms of *Euralia* (*E. mima* and *E. wahlbergi*) mimicking two very different species of *Amauris* (*A. echeria* and *A. dominicanus*) there is good reason to believe that a single species has become dimorphic. Photographs of four *mima* (two male, two female) and four *wahlbergi* (three male, one female) were shown, the whole set having been part of a company of twelve individuals going to rest together on a small clump of fern under a steep kraantz, Umbilo River, Malvern, near Durban, Natal (June 28, 1897). The two forms have also been taken *in coitu*, and have been found together freshly emerged from the pupa on the same tree. Intermediate varieties are also known. If specific identity be established, the case will constitute a new form of mimetic dimorphism in the Lepidoptera, similar to that of the Dipterous genus *Volucella*. All cases of dimorphism in mimetic Lepidoptera hitherto described are either sexual or confined to a single sex. In one sex, indeed, a mimetic species may be polymorphic, as in the female of *Papilio cenea* or *Hypolimnas misippus*.

In the case of the distasteful sub-family *Acræinæ*, the two very different species *A. natalica* and *A. anemosa* were shown captured at Salisbury on the same day. Although entirely different in detail, the pattern of the two species is broadly the same, and during flight would probably appear to be identical. Another even more striking example of Müllerian or synaposematic resemblance was afforded by a set of eighteen specimens belonging to five species of small Acræas captured on the same day (December 31, 1898) in the same locality. The whole group presented a wonderfully uniform appearance in size, shape, colour, and the general distribution of markings.

An example of a Hesperid (*Baoris netopha*) mimic of an *Acræa* (*A. doubledayi*), the two captured on the same day, added another to the rare instances of mimicry in this family. The resemblance is only seen in the attitude of rest, and is confined to the undersides of the wings.

The aberrant Lycænid (*Alæna amazoula*) has a general Acræine aspect, and is very unlike the well-known appearance of its true family. It is probably distasteful, and is resembled with tolerable closeness, especially upon the undersides of the wings, by a day-flying Geometrid moth (*Petovia dichroaria*). They were captured together at Malvern, near Durban, on September 26, 1897.

A most interesting series of injured specimens of butterflies showed the probable attacks of birds or lizards, observations in the field affording strong support to this interpretation. Members of the specially protected conspicuous groups were, as Fritz Müller showed in the case of South America, also subject to attack. Comparatively few of the injuries were inflicted at the junction of the fore and hind wings, or indeed anywhere except at the apex of the fore wing, or, more commonly still, at the anal angle of the hind wing. In many cases the injury was symmetrical, indicating that a piece had been bitten out of both right and left wings during the usual attitude of rest, or as they came together momentarily in flight. The two points of special attack are commonly rendered conspicuous by special marks, and, in the case of the hind wing, structures such as 'tails,' 'eye-spots,' &c. In the *Lycænidæ*, where the 'tails' are rendered still further prominent by movement, many specimens were captured with these parts bitten out from one or both of the wings.

Large additions were also made to our knowledge of mimicry and warning colours in Coleoptera. In the Carabid genus *Anthia*, a probable warning character common to different species consisted in a large, white patch, placed in some species on the sides of the thorax, in others on the anterior surface of the elytra. The general effect was the same, but the anatomical relations entirely alien. The characteristic banded pattern of the *Cantharidæ* was shown to be resembled by beetles of widely different groups, the spotted pattern of the *Coccinellidæ* by a Hemipterous insect (*Steganocerus multipunctatus*), while the appearance of many S. African species of *Lycidæ*, light-brown anteriorly and black posteriorly, was reproduced in beetles of many groups, many species of Hymenoptera, a Hemipteron, two moths from remote sections of the order, and a fly. In the vast majority of these cases of likeness to and among Coleoptera, it is probable that the resemblance is Müllerian (synaposematic) rather than Batesian (pseudosematic). The interpretation of the remarkable likeness borne by a species of Longicorn (*Phantasia gigantea*) for certain *Curculionidæ* is more uncertain, although it is clear that some general principle is at work, inasmuch as resemblances between other species of the same groups are well known in many parts of the world. An interesting group of superficially similar insects from three different orders consisted of a Bracon, a Reduviid bug, and a Longicorn beetle.

Evidence of the struggle for existence in Coleoptera was supplied by a group of five beetles taken from the crop of a Guinea-fowl (*Numida coronata*). The four species belonged to the Buprestids, Curculios, Longicorns, and Phytophaga. All the beetles had been swallowed whole and were almost uninjured, even as regards limbs and antennæ.

Among the other orders of Insecta the Hemiptera afforded a wonderful example of mimicry or common warning colours from Malvern, near Durban, the Reduviid bug *Phonoctonus nigro-fasciatus* bearing the most remarkable likeness to the somewhat smaller Lygæid *Dysdercus superstitiosus*. The mimetic resemblance of Diptera to Aculeate Hymenoptera was illustrated by many examples, model and mimic having been captured in the same place and within the same month. The most remarkable of these was a splendid new species of *Hyperechia*, closely resembling the black, reddish-brown banded, African species of *Xylocopa*, such as *X. flavo-rufa*. Instances of common warning (synaposematic) colours in Hymenoptera were also illustrated by a group of three species with a general resemblance to each other: the Aculeata being represented by a species of *Myzine* and one of *Ceropales*, the Terebrantia by a species of *Ichneumon*. All were captured at Salisbury in January 1899.

The whole of the material here briefly described may be seen in the Hope Department of Zoology, Oxford University Museum.

3. *Observations on Mimicry in Bornean Insects.* *By* R. Shelford, *B.A., Curator of the Sarawak Museum.*

[Arranged and communicated by Edward B. Poulton, M.A., F.R.S., Fellow of Jesus College, Oxford, and Hope Professor of Zoology in the University.]

The following paper is an abstract of results obtained by Mr. R. Shelford, B.A., Curator of the Sarawak Museum, British North Borneo. The vast majority of his observations were made at or near Kuching, the capital of Sarawak; a few, however, in Singapore. When no locality is mentioned, Sarawak is to be understood. The observations form a very important addition to our knowledge of mimicry in Malayan insects, especially the Coleoptera.

Among Lepidoptera an *Elymnias*, believed to be a new species from Mount Penrissen, is a tolerable mimic of the well-known *Euplœa, Tronga crameri*. Among the Chalcosid moths, three species of *Isbarta* mimicked two of *Euplœa* and one of *Pierinæ* (*Delias cathara*). The latter is of considerable interest, inasmuch as the Pierine model appears to be excessively rare. There can be little doubt, however, as to the true relationship, for another species of the same genus, *I. pandemia*, is a magnificent mimic of another species of *Delias* (*D. pandemia*), both coming from Mount Kina Balu in North Borneo.

In the Neuroptera the Mantispides are shown to be mimics, a splendid new species (*M. simulatrix*, McLachlan) resembling a common Bracon flying with it on Mount Matang, near Kuching, while a small species from Singapore (*M.? cora*) exactly mimicked an ichneumon flying with it.

It is in the Bornean Coleoptera, and especially the Longicornia, that by far the largest additions to the subject of mimicry have been made. Many Longicorn species, chiefly of the genus *Oberea*, were excellent mimics of the *Braconidæ*, and perhaps other Hymenoptera. The long narrow form of the beetle resembled the *Bracon* at rest with wings folded. As seen from the side, certain species of *Oberea*, notwithstanding their uniform diameter, were apparently 'waisted' like a Hymenopterous insect, the effect being due to a conspicuous white patch on the side of the anterior abdominal segments. The part of the body thus covered is obliterated, while the outline of the patch is such that the uncovered, and therefore conspicuous, part of the body conforms to the shape of a slender 'waist,' from the posterior end of which the abdomen gradually swells. The effect in one species is as perfect as if an artist had deliberately painted the profile of a Hymenopterous abdomen upon that of a beetle. Among other examples of the same form of mimicry was a magnificent Cerambycid from Mount Penrissen (*Nothopeus* or n. gen., n. sp.), a beautiful mimic of the abundant wasp, *Salius sericosoma*, which flew with it. The common Dammar Bee (*Trigona apicalis*), which does not sting, but is formidable because of its bite, is the centre of a group of three species with the most remote affinities. Not only is there a Longicorn, *Epania singaporensis*, but a *Bracon* and a Reduviid bug. The mimicry is probably Müllerian in most, if not all, of the species of this group.

Another important set of Longicorns, species of *Entelopes*, *Tropimetopa*, *Chreonoma*, and *Astathes* were extremely perfect mimics of Phytophaga (*Galerucidæ*). In one large group both models and mimics were reddish brown, in another iridescent blue-black, in a third anteriorly blue-black, posteriorly reddish brown. Another species of *Entelopes* (*E. glauca*) resembled a common Coccinellid (*Caria dilatata*), a Cassid also falling into the group.

The *Lycidæ* were models for Longicorns and other insects in Borneo no less than in South Africa. Species belonging to the Longicorn genera *Erythrus*

Ephies, *Xyaste*, and *Eurycephalus* mimicked Lycids with remarkable accuracy. In the last-named genus one species, *E. lundi*, was a mimic, while another closely related (*E. cardinalis*) exhibited a warning coloration of the most startling character, an indication that the genus is distasteful and the mimicry Müllerian. In addition to these, the Lycids were mimicked by a Clerid beetle, by numerous Hemiptera and a Zygænid moth, the latter from Singapore.

The resemblance of certain Longicorns to the Rhynchophora was far more evident than in South Africa, for not only was there a mimic (*Trachystola granulata*) of a Curculionid (*Sipalus granulatus*), but there were species belonging to no less than four genera mimetic of the *Brenthidæ*. These latter mimics hold their long antennæ extended forwards side by side, the tips only, or in some species the anterior halves, diverging. Thus the rostrum of the Brenthid, together with its usually short antennæ, are represented by the long antennæ of the Longicorn. The *Anthribidæ* were mimicked by Longicorns of the genera *Ereis* and *Cacia*.

A feature of both Rhynchophorous models and their mimics, and one very unusual in mimicry, is the inconspicuous mottled colouring and the absence of strongly contrasted tints.

A very interesting Longicorn mimic of an Endomychid beetle (*Spathomeles* sp. near *turritus*) was a rare species of *Zelota* as yet undescribed.. The curved spine on the elytron of the model was represented by a brush of hairs on that of its mimic. Experiments indicated that the *Endomychidæ* as a group were distasteful, and large synaposematic sets of purplish black, yellow or orange spotted species were found near Kuching together with several species of *Erotylidæ* and a Pentatomid bug with the same general appearance. Another group of dark Endomychids was rendered conspicuous by numerous spines (*Amphisternus*).

Two groups of Longicorns were mimicked by other Longicorns belonging to entirely different sections. The iridescent green *Cerambycidæ* of the genus *Chloridolum* were closely resembled by two *Lamiidæ* (*Saperdinæ*? genus, and *Chlorisanis viridis*) and by the Cerambycid genera *Xystrocera*, *Psalanta*, and *Leptura*. Many genera and species of the banded Cerambycid *Clytinæ* were very closely mimicked by *Lamiidæ* and other *Cerambycidæ*. This last case is of peculiar interest, inasmuch as the *Clytinæ* are themselves perhaps the most conspicuous mimics of Hymenoptera to be found in the whole of the Longicornia. All over the world their numerous species commonly present a black yellow-banded appearance bearing a general resemblance to wasps, while mimicry of *Mutillidæ*, *Cicindelidæ*, and, in the allied *Tillomorphinæ*, of ants is also found. When, therefore, we also find that this group itself furnishes numerous models to other Longicorns we are driven to conclude that it is in some way specially defended, and that its resemblance to Hymenoptera is Müllerian rather than Batesian.

The mimetic resemblance to the aggressive and active *Cicindelidæ* was very marked, examples being afforded not only by Longicorn beetles of the genera *Sclethrus* and *Collyrodes*, but also by a Dipterous insect found flying together with its model (*Collyris emarginata*) on Mount Seramba, December 1898. This is the first example of the mimetic resemblance of a fly to a tiger beetle. The remarkable Locustid mimic *Condylodera tricondyloides* (or a closely allied species) described by Professor Westwood from Java was also rediscovered in Borneo, and its habits for the first time observed.

Indirect evidence that the mimicry of *Cleridæ* is Müllerian rather than Batesian is similar to that which pointed to the same conclusion in the Longicorn *Clytinæ*. One Bornean species of a Clerid genus (*Thanasimus*) resembled a Mutillid, another (genus near *Tenerus*) a Lycid, while a third, a species of *Lemidia*, was mimicked by the Longicorn *Daphisia pulchella*.

Among the Diptera a splendid black *Hyperechia* (*H. fera*) was a beautiful mimic of the abundant *Xylocopa latipes*, another example of parallelism with South African bionomics. An allied species, *Laphria* sp. near *Terminalis*, was an excellent mimic of *Salius aurosericeus*. Dipterous mimics of Hymenoptera are extremely abundant in Borneo: remarkable among them was a species which mimicked an ichneumon of the genus *Mesosternus*. The short antennæ of the

fly in no way resembled the very long black and white ones of the ichneumon. The fly, however, held up its black and white legs, applying their bases to its head and moving them so that they closely resembled the antennæ of the Hymenopterous insect in movement as well as in colouring and proportions. Another species of fly possessed true antennæ which were remarkably long for this order and thus closely resembled those of an ichneumon.

With few exceptions, the whole of the material here briefly described may be seen in the Hope Department of Zoology, Oxford University Museum.

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Extracted from the PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF LONDON *of October 5th*, 1898.

Prof. E. B. POULTON exhibited a series of *Precis octavia*, (Cram.) var. *natalensis* Staud., and *Precis sesamus*, Trim., both captured and bred by Mr. G. A. K. Marshall at Salisbury, Mashunaland (5000 ft.) and read the following notes thereon:—

"The specimens exhibited prove conclusively (as Mr. Marshall has shown in the July number of 'The Annals and Magazine of Natural History,' p. 30) that these two butterflies, which differ so entirely in appearance and even in shape, size and habits, are seasonal forms of a single species. Mr. Marshall deserves the thanks of all naturalists for this discovery of the most wonderful example of seasonal dimorphism as yet known, and for the generous manner in which he has despatched to this country the invaluable material constituting his evidence, so as to make it accessible for all time in the British Museum and Hope Collection.

"Entomology is deeply indebted to Mr. Marshall for his liberality now and at other times in placing large quantities of valuable material at the disposal of investigators, and for his readiness in undertaking biological observations; and I desire specially to thank him for constant help, and for the valuable information contained in his letters, some of which I hope to lay before the Society.

"The relationship between *Precis octavia-natalensis* and *P. sesamus* has been described by Mr. Trimen (S. Afr. Butt., i, and iii, app.), who connected the two forms by a number of comparatively rare intermediate varieties, which, having regard to the fact that the forms themselves had been captured *in coitu*, he regarded as probably hybrids. The conclusion that the two forms were examples of seasonal dimorphism was reached by Mr. C. N. Barker and independently by Mr. Marshall (Trans. Ent. Soc. Lond., 1896, p. 557).

"Of this conclusion the specimens exhibited furnish absolute proof. They include in the first place specimens captured by Mr. Marshall towards the end of the wet (summer) and beginning of the dry (winter) seasons.

The red form (*natalensis*) was captured on Feb. 13, 1898, (a pair *in coitu*) and Feb. 20, the blue form (*sesamus*), on March 2, 12 and 16, and April 2. The latter form was noted by Mr. Marshall to become dominant about the middle of March.

"Larvæ previously captured also produced *sesamus* at this period, whereas an exactly similar individual that had been placed in a damp jar on March 23 and pupated April 1, produced on April 13 the typical *natalensis* now exhibited. It would be of the utmost value to have many more experiments of the kind.

"Of far greater importance is the fact that Mr. Marshall has succeeded in breeding *sesamus* from *natalensis* in three cases ('Ann. and Mag. Nat. Hist.,' *l.c.*); two are exhibited, the third is in the British Museum. Of the former, one parent laid three eggs on Feb. 27, of which two produced butterflies, one a typical *sesamus* (larva, March 5–31; pupa March 31 to April 15), the other a red *natalensis* tending slightly towards *sesamus* in its heavy black markings and blue-marked border (larva March 5 to April 5; pupa April 5–20). The second parent laid one egg on March 6 which produced a typical *sesamus* (larva March 12 to April 7; pupa April 7—30). This larva was placed in a damp jar from March 30 to April 5, but the 'dry form' of imago emerged. The third example, in the British Museum, is a *sesamus* bred from an egg laid by the summer form on Feb. 13 (larva, Feb. 19 to March 20; pupa, March 20 to April 4).

"As to the meaning of this seasonal dimorphism, I agree with Mr. Marshall's suggestion that the red *natalensis*, appearing as it does in the keener struggle[1] of the warm

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[1] Mr. Blandford has pointed out, and the objection occurred to me independently, that the press of life in the warm damp summer may not, and probably does not, mean greater chance of destruction for any individual insect, the larger needs of enemies being more than compensated for by an increased supply of food. The question can probably be decided on the spot, and I am writing to Mr. Marshall on the subject. In this climate the argument certainly holds good, the danger to individuals of the comparatively few winter species being probably far greater than to those of the numerous summer forms. Granted that somewhat similar conditions exist in S. Africa, it might appear that the mimetic form would be found at the time

damp summer, is probably an incipient mimic of an Acræan type of colour and markings. Mr. Marshall has suggested that *natalensis* presents many similarities to *Acræa acara*, Hew., especially upon the under side of the wings. The resemblance is probably closer when the insects are flying, the most noticeable difference being in the shape of the wings.

"It is in favour of this interpretation that a comparison with allied species of *Precis* tends to show that the blue form is ancestral and the red a recent departure; furthermore, the latter differs from the former and all its allies in the general similarity of the upper and under sides of the wings—a characteristic of the Acræinæ, as of all specially protected groups of butterflies.

"Mr. Marshall's suggestions command increased confidence because of his intimate knowledge of the habits of the two forms. His description of the wide differences therein, as well as in their appearance, is full of interest. The red *natalensis* is described as frequenting higher and more open country, while *sesamus* is found in shady places and gardens, and is distinctly warier and more difficult of approach when not feeding.

"Problems of the deepest interest remain to be attacked.

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of greater stress, viz., the dry winter season. But in England, although there are abundant examples of insects with warning colouring and many which mimic them in the summer, when there is a plentiful supply of palatable food, in winter none are to be seen. Those, such as Coccinellidæ, which exist in the perfect form, hide themselves. The reason probably is that the amount of palatable food available is not sufficient to make it safe to rely on unpalatability, accompanied by warning colouring. Experiments with hungry animals support this view. It is possible that the conditions are similar in S. Africa, and that warning colours are more characteristic of the wet than of the dry season, thus affording greater opportunities for mimetic resemblance. If it should hereafter be shown that *Precis* is to some extent unpalatable, and that its resemblance to an Acræan type is synaposematic rather than pseudaposematic, the parallelism with our own fauna would be even closer, the conspicuous species which hide and thus adopt procryptic habits being represented by one which gives rise to another brood with markedly procryptic colouring and habits. It should be noted, however, that Mr. Marshall (*l.c.*) is strongly of opinion that the species is not unpalatable, and that the colours of the summer form are not aposematic.—E. B. POULTON, November, 1898.

Thus Mr. Trimen has described the pupæ of the two forms as differing, and Mr. Marshall considers that both are certainly procryptic in colouring, that of *sesamus* being gilded and concealed by its harmony with the yellow winter foliage, while that of *natalensis* is dull brownish-black, with black patches on the wings, and is protected among the dark withered leaves of the moist summer. In one case he has bred the red form from a gilded pupa, but never *sesamus* from a dark one. It would be of great interest to ascertain whether these pupæ exhibit true seasonal differences, or whether, as seems more probable, the mature larvæ are susceptible to the colours of their immediate environment, as has been proved to be the case with those of several of the allied Vanessidæ.

"Of still more importance is the decision as to the cause or causes of the seasonal differences of the imago. On this question Mr. Marshall maintains that 'it at once becomes evident that the directly exciting cause is a climatic one' (*l.c.*, p. 37), and he argues that moisture, rather than temperature, supplies the efficient stimulus. The great want in the matter is experimental inquiry on as extensive a scale as possible, carried on over a large part of the year, so as to include larvæ and pupæ, that in the ordinary course certainly produce the blue form, as well as those that produce the red, and those that, at intermediate times, are known to produce both forms.

"Concerning those last-mentioned, Mr. Marshall has shown conclusively that the offspring of a single parent, brought up under the same conditions, may belong to both forms; in fact, in his experiment already described, the summer form emerged five days later (*i.e.*, when the winter season was to that extent advanced) than the winter form. This fact leads us to contemplate the possibility that the change of form is due to internal causes and independent of, although on the whole synchronous with, the seasons.

"And even if some exciting cause be proved to be necessary, it is probable there are great differences in the internally caused degree of susceptibility to stimulus in the two seasons, while a mixed susceptibility exists in the intermediate period.

"It is likely that Mr. Marshall's observations are to be explained by one or other of these alternatives."

The President discussed Prof. Poulton's exhibit, and also congratulated Mr. Marshall on the importance of his discoveries.

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Mr. F. Merrifield read a paper, illustrated by a large number of specimens, on "The Colouring of Pupæ of *P. machaon* and *P. napi* caused by the exposure to coloured surroundings of the larvæ preparing to pupate."

It had generally been considered that the larva of *P. machaon* was insusceptible to its surroundings when at the period of pupation, but at the instance of Prof. Poulton he had tried experiments last summer which proved that this was not the case. Of eleven pupæ of the first brood obtained in July, six larvæ were set to pupate on dark sticks; four of these were of the bone-coloured form, but a fifth was intermediate and the sixth fell to the earth, where it formed a green misshapen pupa. Of the five larvæ set to pupate on white sticks of peeled willow, four pupated on them and were all green, the fifth pupated on the white muslin top and was bone-coloured. Of seven other pupæ that were found to have attached themselves to the stems of the green carrot tops on which they were fed, six were green and one bone-coloured. This made a strong case, but experiments tried on a larger number of the larvæ of the second brood in September were conclusive. Of 16 pupated on black paper or dark sticks, all but one were bone-coloured, and most of them dark, four that pupated on green carrot tops were all green, and of 19 others that pupated on yellow or orange all but one were green. Various intermediate colours gave mixed results; absolute darkness produced five bone-coloured pupæ but of a pale hue. Seventy-two pupæ had been obtained, and all these were exhibited, as were the pupæ or pupa-cases of the eleven of the summer brood that had pupated. Several hundred pupæ of the second brood of *P. napi* were also exhibited, and these were shown to be exceedingly sensitive. Of ten on black

paper all were dusky with much spotting of dark brown, so were seven out of eight on dark sticks, the eighth being green. Of twelve on green cabbage leaves or on the glass of the bottle containing them the majority were green or greenish; seven out of eight of those on yellow paper, and all the eleven on orange leno were green; of seven in absolute darkness six were green, two much spotted with dark brown, one bone-coloured with much spotting. He also exhibited 28 pupæ of *P. brassicæ* and about 40 of *P. rapæ*, with results in accordance with those obtained and recorded by Prof. Poulton. In the case of both these species he had some confined during the whole period of susceptibility to clear glass, with no substances near that reflected any colours or white or black; the results very nearly resembled some kept in absolute darkness, except that those on the clear glass were a little darker. One very interesting *napi* exhibit was that of the sheet glass roof of a breeding cage in two compartments, one having the interior partly orange and partly yellow, the other black; in the orange-yellow compartment 46 had pupated on the roof on which orange leno had been placed, transmitting orange light, and all but four of these were green with very little dark spotting; in the other compartment 34 had pupated on the glass roof which had been covered outside with opaque black paper and all of them were bone-coloured, most of them much spotted with dark brown. He thought it was impossible to doubt that much of the colouring was protective.

Mr. Bateson said that he had lately bred *P. napi* on a large scale, and as regards that species he could quite confirm Mr. Merrifield's observations. His own experiments had been undertaken with a different object, but he had frequently noticed that there was a fairly close correspondence between the colour of the pupæ and that of the substances to which they were attached, though exceptions to this rule were not uncommon. He had moreover observed that in this respect there was considerable difference between different families of larvæ. In his experiments the offspring of each pair were kept separate, and in some families many larvæ pupated on the food plant, while in others scarcely any did so. In some families the pupal colours conformed in nearly every case,

while in other families the unconforming pupæ were numerous The pupæ were often clustered together in little groups, and individuals composing such clusters sometimes agreed with each other in conforming or in not conforming.

He did not propose on that occasion to discuss the general proposition that the colour-resemblance was in these cases a protection; but he pointed out that if a larva had the power of forming a green pupa when attached to a green plant the conformity of colour would make the pupa less conspicuous only so long as the plant remained green. In the case of the summer brood of *napi*, for instance, this resemblance might perhaps be effective, though in this case the pupal period was very short, only two or three weeks. But in order that the resemblance may benefit pupæ which over-winter it is necessary that the green plant to which green pupæ are attached should remain green in the winter. His own pupæ had turned green on several food-plants which wither and go brown: in these cases the pupæ became conspicuous again.

To form a sound judgment on this matter it would be necessary to know how the pupæ occur in nature. Pupæ of *P. napi* were hard to find. Had any one found the green pupæ in the wild state?

Prof. POULTON wished to congratulate Mr. Merrifield on the results he had obtained. He was particularly interested to know that the pupæ of *P. machaon* had now been proved to be sensitive. His own experiments on the species led him to infer the opposite, but they had been conducted with very few individuals, and he had always hoped that the species would be investigated on a large scale.

The results obtained by Mr. Merrifield upon *Pieris napi* were very striking and showed that the mature larvæ were most sensitive to the colours of their surroundings. The strong influence of orange and yellow backgrounds in producing green pupæ was corroborated by his own experience and confirmed the conclusion reached in his earlier experiments, that the efficiency of the greens of nature in producing green pupæ (and larvæ) in sensitive species was due to the orange and yellow rays which they reflect.

He exhibited some pupæ of *Pieris brassicæ* which had been

rendered black-spotted and green by black and yellow surroundings respectively, and a few pupæ of *Papilio podalirius* which seemed to indicate that that species was sensitive. In some experiments which he had conducted during the past summer upon the struggle for existence in pupæ, very large numbers of pupæ of *Vanessa urticæ* were produced upon backgrounds of various colours, with results which confirmed the conclusions he had already recorded. He hoped soon to bring a detailed account of these observations upon pupal colour-adaptation before the Society.

Replying to Mr. Bateson's objections to the interpretation of the colour-susceptibility of the pupæ of *Pieris napi* as of protective value, he considered that it was in every way probable that the larvæ wandered before pupation (as those of allied species were known to do) and that their power of becoming green was of value when they were fixed to grasses or other plants which remain green through the winter. Even if all such green surfaces were covered up with snow in the more northern part of the range of the species, this would not be the case for the whole of the winter pupal period, nor would it hold good for other parts of the range. As to the objection that the results obtained with bred pupæ were not invariably consistent, in his experience the more completely the experiment was conducted with this sole object in view, the more uniform and convincing was the result.

Furthermore, the conditions of even the most carefully conducted experiments differed in many respects from those which obtained in nature. The proof required by those who objected to an interpretation based on natural selection was the discovery *in nature* of the exceptions noted in their experiments—that of light green pupæ of *P. napi* or *P. rapæ* or the golden or green pupæ of *Vanessæ* upon grey stone, or the dark forms of all these upon leaves.

Although some of these pupæ had been often observed in one or both situations he had not heard of any single exception to the rule; and if they occurred they must be excessively rare.

XIII. *The Colour-relation between the pupæ of* Papilio machaon, Pieris napi *and many other species, and the surroundings of the larvæ preparing to pupate*, etc. By F. Merrifield, F.E.S., and Edward B. Poulton, M.A., F.R.S., etc., Hope Professor of Zoology in the University of Oxford.

[Read October 5th, 1898.]

A.—INTRODUCTORY. (F. Merrifield and E. B. Poulton.)

B.—EXPERIMENTS UPON THE PUPÆ OF *Papilio machaon.*

1. *Experiments upon the Summer Pupæ of* Papilio machaon. (F. M.)
2. *Results of the above Experiments.* (E. B. P.)
3. *Experiments upon the Winter Pupæ of* Papilio machaon. (F. M.)
4. *Results of the above Experiments.* (E. B. P.)
5. Mr. C. V. A. Peel's *Winter Pupæ of* Papilio machaon *described.* (E. B. P.)

C.—EXPERIMENTS UPON THE PUPÆ OF *Papilio podalirius.* (Cora B. Sanders and E. B. P.)

D.—EXPERIMENTS UPON THE PUPÆ OF *Pieris napi.*

1. *Experiments upon the Winter Pupæ of* Pieris napi. (F. M.)
2. *Results of the above Experiments.* (E. B. P.)

E.—EXPERIMENTS UPON THE PUPÆ OF *Pieris brassicæ.*

1. *Experiments upon the Winter Pupæ of* Pieris brassicæ. (F. M.)
2. *Results of the above Experiments.* (E. B. P.)
3. *Experiments upon the Winter Pupæ of* Pieris brassicæ. (E. B. P.)
4. *Experiments with conflicting colours upon the Winter Pupæ of* Pieris brassicæ. (E. B. P.)

F.—NOTES ON THE STRUGGLE FOR EXISTENCE IN THE LARVÆ OF *Pieris brassicæ.* (E. B. P.)

G.—EXPERIMENTS UPON THE PUPÆ OF *Pieris rapæ.*

1. *Experiments upon the Winter Pupæ of* Pieris rapæ. (F. M.)
2. *Results of the above Experiments.* (E. B. P.)

H.—EXPERIMENTS UPON THE PUPÆ OF *Vanessidæ*.

1. *Experiments upon the Pupæ of* Vanessa urticæ *and* Pyrameis cardui. (C. B. S. and E. B. P.)

2. *Experiments upon the Pupæ of* Vanessa io. (MABEL E. NOTLEY, FLORENCE A. WRIGHT and E. B. P.)

I.—EXPERIMENTS AND OBSERVATIONS UPON THE SUSCEPTIBILITY OF CERTAIN LEPIDOPTEROUS LARVÆ AND PUPÆ TO THE COLOURS OF THEIR SURROUNDINGS. (A. H. HAMM and E. B. P.)

K.—OBSERVATIONS ON THE COLOUR-RELATION BETWEEN A COLEOPTEROUS SPECIES (*Cleonus sulcirostris*) AND ITS SURROUNDINGS. (W. HOLLAND and E. B. P.)

L.—APPENDIX. THE QUALITY OF LIGHT REFLECTED FROM THE COLOURED AND OTHER BACK-GROUNDS EMPLOYED IN THE EXPERIMENTS RECORDED IN THE PRESENT MEMOIR. (SIR JOHN CONROY, F.R.S., and E. B. P.)

A.—INTRODUCTORY.

IN Prof. Poulton's paper in the Philosophical Transactions of 1887, vol. 178 B. pp. 311–441, "An Enquiry into the Cause and Extent of a Special Colour-relation between certain exposed Lepidopterous Pupæ and the Surfaces which immediately surround them," he recorded some experiments on the full-fed larvæ of *Papilio machaon* from which he inferred that this species was not susceptible to the colours of its surroundings, a conclusion which surprised him, having regard to the marked dimorphism of the pupæ [the larva not showing any corresponding dimorphism to which the different colours of the pupæ could be ascribed, as in the case of the geometrid genus *Ephyra* (Phil. Trans. *l. c.* p. 437)], and Prof. Poulton suggested that further experiments should be tried, more especially as he had had only eleven larvæ, of which two died. At the meeting at Cambridge in August last of the International Congress of Zoology M. Bordage of Réunion communicated a paper in which he expressed the opinion that the pupæ of the genus *Papilio* appeared to have lost any susceptibility to colour which they might at one time have possessed, but Mr. Trimen, your President, gave an instance to the contrary, and expressed the opinion that too few experiments had been made to warrant at present any conclusion on the subject.

Early in July last I happened to mention to Prof. Poulton that I had then a considerable number of larvæ of *P. machaon* which I had received from Germany, and at his suggestion I experimented on some of those I had left at this time, receiving much useful information from him personally as well as from the very full record of his experiments on other species, in the paper above referred to, and in his subsequent paper in the Transactions of this Society for 1892, pp. 293–487.

The experiment thus begun gave rise to many other experiments in which different species were employed. The results were in large part displayed and an account given of them at the meeting of this Society on October 5th, 1898 (Proc. Ent. Soc. Lond. 1898, pp. xxx—xxxi). Professor Poulton was at the meeting and also showed the results of some further experiments he had been making in 1898 (Proc. Ent. Soc. *l. c.* pp. xxxii—xxxiii). The same day I suggested to him that it would be useful to arrange the results of my experiments according to the standards of colour which he had already published, and construct fresh standards for the species with which he had experimented but little or not at all. He approved the suggestion and agreed to arrange the results accordingly, and also offered to include the results of the experiments he had recently made.

This memoir accordingly appears in our joint names. The name or initials of the worker who conducted the investigation will appear in the heading of each description. Professor Poulton is responsible for the new standards of comparison and the tabulation of all the pupæ. In arranging the pupæ, he allowed due weight to the description of my results so far as I had made one.

F. Merrifield.

A few brief words are all that are necessary to form my introduction to our joint paper; inasmuch as Mr. Merrifield has fully explained the circumstances under which it came to be written. I was only too pleased to act upon his suggestion, and thus to combine the record of our investigations. It is more convenient in every way that there should be a single complete account instead of two less complete ones. The method adopted of placing the initials of the writer after the title of each Section he has communicated makes our individual responsibility perfectly clear.

A portion of my investigations were carried on jointly with Miss Cora B. Sanders, of Lady Margaret Hall, Oxford. These Sections are preceded by her name or initials as well as my own.

The experiments upon the colours of the pupæ of *Vanessa io* were carried on, under my direction, by Miss Mabel E. Notley and Miss Florence A. Wright, of Lady Margaret Hall. Their names are added to the title of the Section in which the experiments are described.

Some interesting observations of Mr. A. H. Hamm and Mr. W. Holland of the Hope Department of Zoology, Oxford, form in large part or entirely the subjects of two Sections to which their names have been added.

Sir John Conroy, F.R.S., very kindly helped me in determining the quality of the light reflected from the various backgrounds, and his name has been similarly added to the Appendix in which our results are described.

I wish also warmly to thank Mr. W. Holland and Mr. A. H. Hamm of the Hope Department for their most efficient help in many parts of the work; Mr. C. V. A. Peel for kindly lending specimens which have been described, and Mr. Arthur Sidgwick and Mr. Nicholson for drawing my attention to interesting observations made by them which are recorded in Section I.

E. B. Poulton.

B.—EXPERIMENTS UPON THE PUPÆ OF *Papilio machaon.*

1. Experiments upon the Summer Pupæ of *Papilio machaon.* (F. M.)

I am generally away from home from nine or ten o'clock until five or later, and therefore my opportunities for taking a larva just at the right moment, when it has done feeding and before its sensitiveness to colour has begun, are imperfect. But I was able to select fourteen larvæ, which seemed to have arrived at the full-fed stage, and I prepared a few glass cylinders of about 6 inches in height and mostly $3\frac{1}{4}$ inches in diameter, though some were an inch or two wider, which I placed in flower-pots nearly filled with earth. They were in two divisions, viz. (1) furnished with dark sticks, and (2) furnished with light sticks. Division (1) had about six dark brown sticks of from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch in diameter taken from an old

faggot-stack, and had a roof of black net. Division (2) had the same number of peeled and therefore nearly white willow slips of the same size, and had a roof of white muslin. The sticks were secured by driving them into the earth, and the cylinders were in both cases exposed to the same amount of light, *i. e.* close to a rather large window, but on most days moved from the W.N.W. to the E.S.E. side of the house, and back, to avoid hot sunshine. As larvæ, where crowded, have been found to affect each other's pupal colouring (Phil. Trans. 1887, *l. e.* Ent. Trans. 1892, *l. e.*), only two or three were placed in each cylinder.

I exhibit the eleven pupæ or pupa-cases, which were obtained under these conditions. As the dark pigment resides in the pupa-case, it is easy to see on examining this whether the pupa was a green one or not, as, if the pupa was a green one, the pupa-case is practically free from pigment, though sometimes stained in places by the meconium, whereas if the pupa was bone-coloured the case is much darkened by brown or black markings.

It was obviously desirable to ascertain what was the proportion of *grey* * and *yellow-green* pupæ in my stock, and on going through the whole remainder of them, 145 in number, I found that 76 might be described as of the former and 69 of the latter or yellow-green form. Many of these however were of intermediate colouring, and it was not easy to classify them. Seven of the 145 had pupated on the green carrot-tops on which the larvæ had been fed; of these six were *yellow-green*, one was *grey*.

This made a very strong case for susceptibility, but it was not conclusive, and I determined to try the experiment on a larger scale with the second brood.

Before describing in detail the results of this and other experiments it is necessary to tabulate the colours which the pupa of *P. machaon* is known to assume, so as to have a standard of comparison. The following table and description were made by Prof. Poulton on May 2nd, 1899, after carefully comparing the whole of my pupæ together with a number belonging to Mr. C. V. A. Peel.

2. Results of the above Experiments. (E. B. P.)

There is a distinct dimorphism in the pupæ of *Papilio machaon*, and the intermediate forms are very rare as

* See note on page 374.

compared with the extreme. The two forms may be classified as (1) *yellow-green*, and (2) *grey*.* The former have a yellow ground-colour with deep green markings, the latter a bone-coloured ground with dark purplish brown, and in places black markings. With few exceptions the dark markings of the *grey* forms correspond in position with the green markings of the *yellow-green* forms, the chief exceptions being on the surface of the pupal wings, where the green forms a more continuous area, less interrupted by the yellow ground-colour than the dark marking is by bone-colour.

This correspondence in position becomes all the more interesting and remarkable when it is remembered that the two markings are entirely different in constitution, origin, and even in the pupal layers in which they are respectively situated, the green pigment being relatively unstable, probably a modified form of chlorophyll derived from the food-plant, and situated in the deeper laminated layers of the pupal cuticle, the dark pigment being very stable (remaining permanently in the empty pupal case), solely due to the metabolic activity of the animal organism, and confined to the thick layer of cuticle which lies above the laminated layer and forms the outermost part of the pupal shell. (See Poulton, Proc. Roy. Soc. 1885, Vol. xxxviii, p. 279, in which however the laminated layer is erroneously distinguished from the "true cuticle.")

We can again classify the (1) *yellow-green* and (2) *grey forms* as (*a*) *dark* and (*b*) *light*, thus :—

1. *Yellow-green*	*a.* *Light forms.*	
	b. *Dark*	,,
2. *Grey*	*a.* *Light*	,,
	b. *Dark*	,,

* I formerly spoke of the darker pupæ as *brown* (Phil. Trans. 1887, *l. c.* p. 407), a description which is clearly incorrect. Mr. Merrifield has introduced the appropriate term "bone-coloured," which accurately expresses the appearance of the ground-colour of these pupæ as well as those of the corresponding forms of *Pieris napi* and *P. rapæ*. The whole appearance of these pupæ is however due to the combined impression made by the pale ground-colour and the dark markings, and I think that "*grey*" expresses this effect as a whole more truly than any other word ; although there are pupæ in which the markings are so inconspicuous that the effect seen is that of the ground-colour alone.

E. B. P.

A *light yellow-green* form (1 *a*) is bright yellow over the dorsal surface slightly mottled with green on the sides, this colour becoming distinct round the spiracles and forming a spiracular streak interrupted between the abdominal segments. At the posterior extremity of the pupa this green streak is continued on to the sides of the anal spine, and in the more strongly marked pupæ of this degree the whole of the spine is green. The green mottlings are rather more distinct upon the abdominal segments below the spiracular band than they are above it, and have a more pronounced longitudinal arrangement. The dorsal region of the thorax is also more or less mottled with green which becomes concentrated to form a distinct apical patch on the mesothoracic median spine. The wings, limbs, antennæ, and head are deep green, the latter being, in the palest pupæ, the most strongly coloured part of the whole surface.

In the more deeply coloured of the light forms (1 *a*) the mottled green tends to spread backwards from the mesothoracic spine forming a broad indistinct greenish band.

In the *dark yellow-green* pupæ (1 *b*), further development and coalescence of the mottlings transform this dorsal band into deep green. It occupies the whole dorsal area between the subdorsal rows of small tubercles. Below, the green of the spiracular stripe,—continuous in pupæ of this degree —spreads upwards and invades the yellow ground-colour leaving only a yellow lateral band, sharply defined above where it terminates at the level of the subdorsal tubercles, while below it gradually passes into the invading green. Anteriorly this yellow band terminates below the mesothoracic spine. The dorsal green band is palest (yellowest) in its median part and in the posterior half of its length, in front of the caudal spine, the dorsal surface of which is green. The band is also interrupted in the region of the metathorax by a yellow patch, traversed by a green median line.

The *light grey* forms (2 *a*) resemble the *light yellow-green* (1 *a*), substituting bone-colour for yellow, and dark purplish-brown for green, allowing of course for the greater contrast between ground-colour and marking which is thus brought about, and for the difference over the wings which has been already alluded to.

The *dark grey* forms (2 *b*), by making a similar substitu-

tion, resemble the *dark yellow-green* (1 *b*). The purplish-brown is increased in extent as is the green of the corresponding form (1 *b*), the dark dorsal band becoming a specially prominent feature which contrasts strongly with the appearance presented by the *light grey* pupæ (2 *a*).

I will now apply the arrangement suggested above to the results of Mr. Merrifield's experiment. The pupæ were compared on May 2nd, 1899. Three of the 14 larvæ died without pupating. Of the remaining 11, 6 had been placed in the cylinders furnished with dark sticks; 5 of these pupated on the dark sticks. In comparing these summer pupæ and putting each in its place in the scale of colour, great assistance was derived from Mr. Merrifield's descriptions made in 1898, when more of the pupæ were alive and those which were dead had changed less extensively.

All the pupæ attached to dark sticks were clearly *grey* forms (1), except one (probably dead), which was intermediate between *yellow-green* and *grey*, having a bone-coloured ground with many of the markings, especially upon the wings, greenish instead of brown. Of the remaining 4 pupæ, 1 had emerged in 1898, and was intermediate between *dark* and *light grey* (2 *a*, *b*) or a lightish *dark grey* (2 *b*); 1, still alive, was also a (2 *a*, *b*); 2, dead, were certainly *grey*, and probably *dark grey* (2 *b*).

The sixth pupa was dead and much discoloured, but from Mr. Merrifield's description in 1898, it had evidently been a *yellow-green* form (1 *a*) or (1 *b*): "The larva had imperfectly attached itself to a dark stick and had then, before pupating, fallen on the earth which, being moist, was of a dark colour. It had there formed a yellow-green pupa, somewhat misshapen."

Of the 5 placed in light surroundings, 4 were attached to shaved white sticks.

Two were dead, but both were evidently *yellow-green*, one probably a *light* and the other a *dark* form of this degree, (1 *a*) and (1 *b*).

Two had emerged, but both had been *yellow-green* and one certainly a *light* form (1 *a*), the other probably *dark* (1 *b*).

The fifth pupa, attached to the white muslin top, had also emerged. This pupa was an exception, being a distinct *light grey* form (2 *a*).

3. Experiments upon the Winter Pupæ of *Papilio machaon.* (F. M.)

In order to continue the experiments, begun upon the summer pupæ, I obtained from Germany, from the 31st of August to the 2nd of September, 1898, about 150 more larvæ, most of them young.

Apparatus.

In order to cope to some extent with the difficulty I had in taking the larvæ just at the right moment, owing to my long daily absences from home, I provided two special breeding-cages. These were made of $\frac{5}{16}$ inch deal, each in two compartments. Thus there were four compartments the external dimensions of which were 16 inches in height, 12 inches in depth from front to back, and 8 inches in width. The front of each cage was a sheet of glass, about 14 inches in width and 12 inches in height, as it started at 3 inches from the bottom; it was vertically divided down the middle by the thin deal partition between the two compartments. The backs were of perforated zinc, corresponding in size with the glass fronts, and the outer sides were of deal containing the doors. The tops were open, but covered with woven material as stated below. The framework of the top, and generally, was about an inch wide, and there were many angles more or less shady, vertical, and horizontal, where the parts of the framework met at right angles.

The compartments were covered internally as follows:—The whole of the interior, except the glass front and the perforated zinc backs, was covered with tissue-paper; black in the black compartment, white in the white compartment, green in the green compartment, and about one-half orange and one-half yellow (the division being vertical) in the orange-yellow compartment. The perforated zinc backs and the open tops were covered with woven material, viz. the black compartment with double black muslin (covered with a slate), the white compartment with double white calico, the green compartment with threefold yellow-green art muslin (fourfold on the top except for the *brassicæ* experiment hereafter described when it was twofold), the orange-yellow compartment with orange-yellow leno; this leno, instead of paper, being also used in some of the angles of the framework.

The fronts of the cages were placed within a few inches

of a second-floor window about 3 feet wide and 6 feet high, they were facing the W.N.W. and looking into an open country, and were often screened by a muslin window-blind during hot sunshine. No direct light from the sky reached any part of the interior except a small part of the bottom and of the sides.

Much orange light came through the roof of the first compartment, very little greenish light through the top of the green compartment, and much white light through the top of the white compartment; in addition to white direct light, much was reflected from the coloured interior of these three compartments, but the black compartment was very dark inside except the part close to the glass front.

The effect was that the black compartment was for the most part very dark; the white, green and orange-yellow compartments much lighter, as the tops transmitted much light, and the colours were such as to reflect a great deal of light. In the green compartment, however, while covered with the fourfold art muslin, very little light came through the top. In all cases a little light came in through the chinks of the doors, and a very little through the draped perforated zinc at the back. In all four compartments there were shady regions in the angles of the framework, and I found so many of the larvæ had a disposition to select these shadier regions for pupating, where of course the coloured light would operate less strongly, that I found it expedient to transfer them, when I could do so in time, to receptacles where they were exposed to stronger light. For these purposes I prepared glass cylinders of the dimensions before mentioned, covered at the bottom and for about two-thirds of the outside circumference with paper of the appropriate colour, leaving clear the one-third next the window, and the tops being usually covered with paper of the same colour, but sometimes with clear glass. In this way I fitted up cylinders for the following colours: black, white, green, yellow, orange, Dutch "gold," all provided with sticks covered with paper of the corresponding colour. These cylinders were placed on thin pieces of wood or cork carpet with tintacks driven through the bottom, forming spikes on which the coloured sticks were fixed. The bottoms, as well as about two-thirds of the circumference opposite the light, and the tops, were covered with single or double paper of the proper colour

secured by three ties of thread and on the tops by a sheet of clear glass. In the case however of the dark sticks the bottom was of dark cork carpet, and these cylinders were clear all round, with a sheet of clear glass on the top.

In order not to crowd the larvæ, it was my practice to transfer them, when spun up on the sticks, to wide-mouthed Bordeaux plum-bottles of clear glass having a greenish hue, of about the same size as the cylinders, but fitted for two-thirds of their circumference with coloured paper inside instead of outside, and I sometimes transferred larvæ direct from the compartments of the breeding-cage to these bottles, as pupating against glass in front of coloured paper did not appear to me to be the same thing in effect as pupating against the coloured paper. In these bottles the coloured paper was inside, and therefore nearer the larvæ than in the cylinders. The sticks in the bottles could not be prevented from shifting as heavy larvæ crawled over them, and the larvæ appeared to dislike this, and to be more restless and slower in pupating than when the sticks were fixed.

The cylinders and bottles were placed within a few inches of the window above referred to, or of another window having the same aspect, but only about 4 feet high by 3 feet wide. As the objects in both were necessarily near the light, and, except in those given over to black, light, coloured or uncoloured, was admitted all round and by the tops, the larvæ in these were as a rule exposed to much more light, both direct and reflected, than those in the breeding-cages.

I also lined a clear glass saucer with green carrot-tops and placed it in a second saucer with green carrot-tops, among which some larvæ pupated, the surface being covered with a sheet of clear glass.

Most of the *machaon* larvæ in the cylinders or bottles spun up against the coloured sticks provided for them, but in a few cases they spun either against the glass where it was covered outside by coloured paper or against the clear glass front of the cylinder or bottle. In these cases I always classified the pupæ as "orange through glass" or as "orange on glass," the pupæ in the latter case being often not near the special colour, although the larvæ in moving about had probably been at times exposed to the colour influence. If, however, these larvæ follow the same laws as those of *Vanessa urticæ*, they are only sensitive when

at rest on the surface upon which they will afterwards pupate. (Phil. Trans. 1887, *l. c.*) Allowance must be made, on the other hand, for the possible disturbance of larvæ after they have entered the susceptible phase.

Colours of the different surroundings.

Besides these black or coloured cylinders or bottles I had clear glass cylinders or bottles supplied with the other objects enumerated below for the pupæ to attach themselves to, some also being shut up in absolute darkness. The result was that I obtained several classes of pupæ, viz. from—

1. Black paper (*a*) in strong light, (*b*) in more or less shade.
2. Dark sticks from old faggots or freshly-cut dark alder.
3. Dirty white paint, being that of a breeding-cage ten years old.
4. Darkness.
5. Light-coloured dry stems (dead stems of *Epilobium hirsutum*).
6. Dead reeds, light brown in colour.
7. Dull green reeds.
8. Bright golden yellow oatstraw.
9. Dutch "gold," with embossed pattern.
10. Green paper (*a*) in strong light, (*b*) in more or less shade.
11. Green carrot-tops.
12. White paper (*a*) in strong light, (*b*) in more or less shade.
13. Yellow paper (*a*) in strong light, (*b*) in more or less shade.
14. Yellow orange leno (*a*) in strong light, (*b*) in shady corner.
15. Orange paper (*a*) in strong light, (*b*) in shady corner.

Some of these had the further differences which are indicated in the exhibit and described in the classification of the pupæ.

I exhibit the results of all these exposures, 72 individuals. All of these may repay study; the details will be described by Prof. Poulton. I could perhaps have made the Exhibition Case more attractive as well as more effective for purposes of comparison had I detached the pupæ from the

coloured backgrounds that in most cases adhered to them; but I thought it eminently desirable that the exhibition should supply its own evidence, so as to enable all who see it to draw, independently, their own conclusions. I supplement it, however, with all the other pupæ obtained in the course of my experiments. As general results it will be enough perhaps here to say that the 16 pupæ of *P. machaon* on the black paper-covered sticks and on dark natural sticks are all *grey*, with the exception of one, which is *yellow-green;* those that were in a strong light are very dark; that of the 4 on carrot-tops all are *yellow-green;* that of the 9 on white paper 1 is *grey* and the other 8 all *yellow-green* or *light grey* with a greenish tinge; that of the 6 on yellow paper 2 are *greenish-grey* and the other 4 *yellow-green;* and that of the 4 on orange paper all are *yellow-green.*

These results seem to me clearly to prove the susceptibility of *P. machaon.*

The pupæ of *P. machaon* on the other coloured surroundings employed did not give such definite results; particulars are given in the next section.

4. Results of the above Experiments. (E. B. P.)

The pupæ were compared May 2nd, 1899.

The various conditions to which the larvæ of *P. machaon* were subjected will be considered in the same order as that adopted by Mr. Merrifield on p. 380.

(1) black paper. (*a*) *In strong light.*

2 pupæ, fixed to black tissue-paper, were very *dark grey* (2 *b*).
1 pupa, fixed to black tissue-paper, was intermediate between *dark* and *light grey* (2 *a*, *b*).
1 pupa, fixed to black tissue-paper, had emerged, and was *grey*, probably similar to the last.
1 pupa, fixed to black net, was dead, and was *grey*, probably similar to the last.
5

(*b*) *In fair light.*

The single pupa (dead and discoloured) was fixed to black net. It was impossible to place it with any certainty, but the appearance suggested that it had been *yellow-green.*

(c) In a dark corner.

All the pupæ were fixed to the black paper.

1 pupa was very *dark grey* (2 *b*).
3 pupæ (one dead) were *grey*, probably *light* (2 *a*).
1 pupa was *grey*, probably intermediate between *dark* and *light* (2 *a*, *b*).

5

(2) DARK STICKS (ONE MUCH LIGHTER THAN THE REST).

All the pupæ were attached to the sticks.

2 pupæ were *dark grey*, (2 *b*) one very dark.
1 pupa, on the lightest bark, was *light grey* (2 *a*).
2 pupæ (dead) were *grey*, probably *light* (2 *a*).
1 pupa (dead) and much altered, was probably the *yellow-green* form (1) described by Mr. Merrifield on p. 381.

6

(3) DIRTY WHITE PAINT.

1 pupa, fixed to the painted surface, was intermediate between *dark* and *light grey* (2 *a*, *b*), but with some tendency, in the possession of a greenish tinge, towards the *yellow-green* form (1).
1 pupa, fixed to the painted surface, was dead and changed in colour, but it had probably been *yellow-green* (1).

2

(4) DARKNESS.

2 pupæ were intermediate between *dark* and *light yellow-green* (1 *a*, *b*).
1 pupa (dead) had altered in colour, but had been a *light* form of either (1) or (2).
1 pupa was probably *light yellow-green* (1 *a*), but had darkened, apparently preparatory to emergence.
1 pupa was intermediate between (1) and (2) and also intermediate between dark and light (*a*, *b*).

5

The absence of strong pigmentation, and the tendency towards *yellow-green* rather than *grey*, were the marked results of darkness, so far as these 5 pupæ are concerned.

(5) LIGHT-COLOURED DRY STEMS (*Epilobium hirsutum*).

1 pupa (dead and discoloured) was probably *light grey* (2 *a*).
1 pupa (dead, or perhaps discoloured, preparatory to emergence) was probably a *yellow-green* form (1).

2

(6) DEAD, LIGHT BROWN REEDS.

Both pupæ had become greatly discoloured, and one at least was dead. The position of one was uncertain; the other had apparently been a *yellow-green* form (1).

(7) DULL GREEN REEDS.

1 pupa, fixed to reed, was intermediate between *dark* and *light grey* (2 *a*, *b*).
1 pupa, fixed to reed, was intermediate between *grey* and *yellow-green* (1, 2).

2

(8) OATSTRAW (BRIGHT GOLDEN YELLOW).

1 pupa, fixed to straw, was a *light grey* form (2 *a*), with some tendency towards *yellow-green*.
1 pupa, fixed to straw (dead and discoloured) was of uncertain position, but clearly it had not been highly pigmented.

2

(9) DUTCH "GOLD" (EMBOSSED).

1 pupa, fixed to "gold," was intermediate between *dark* and *light grey* (2 *a*, *b*), with a slight tendency towards the *yellow-green* form (1).
1 pupa, fixed to "gold" (dead), was intermediate between *dark* and *light yellow-green* (1 *a*, *b*).

2

(10) GREEN PAPER. (*a*) *In strong light.*

1 pupa was *dark yellow-green* (1 *b*).
1 pupa was *light grey* (2 *a*).
1 pupa was dead and of uncertain position, but probably it had never been strongly pigmented.

3

(b) In good light.

The single pupa was dead and discoloured, and its position uncertain. It was obvious however that it had not been strongly pigmented.

(c) In fair light.

1 pupa was intermediate between *light yellow-green* and *light grey* (1 *a*, 2 *a*).
1 pupa (dead or emerging) was probably a *yellow-green* form (1).
—
2
═

(d) In shady corner.

1 pupa was *light grey* (2 *a*).
1 pupa was intermediate between *light* and *dark grey* (2 *a*, *b*).
—
2
═

(e) Fixed to glass near the green paper.

The single pupa was dead, and so discoloured that it could not be placed.

Hence green paper is far less powerful than yellow or orange paper (Nos. 13, 14, 15), or the natural green of chlorophyll (No. 11) in the production of green pupæ of this species, thus agreeing with the results already obtained in the case of other species (Phil. Trans. 1887, and Trans. Ent. Soc. 1892, *l. c.*). It is noteworthy that the most shaded part of the green surface produced the strongest tendency towards *grey* forms.

(11) GREEN CARROT-TOPS.

1 pupa was intermediate between *dark* and *light yellow-green* (1 *a*, *b*).
3 pupæ (dead or emerging) were *yellow-green*, probably of the same shade as the above (1 *a*, *b*).
—
4
═

(12) WHITE PAPER. *(a) In strong light.*

4 pupæ were *light yellow-green* (1 *a*), one of them with a tendency towards *grey* (2), and one very remarkable in possessing an almost *white* ground.
1 pupa was intermediate between *light* and *dark yellow-green* (1 *a*, *b*).

1 pupa was discoloured, but had probably been intermediate between a *light* and *dark grey* (2 *a*, *b*).

6

The form with white ground perhaps indicates some special influence of the surroundings in the direction of producing a peculiarly close resemblance; but more experiments are needed in order to render it certain that the case was not that of a rare individual peculiarity.

(*b*) *In fair light.*

1 pupa was intermediate between *light* and *dark yellow-green* (1 *a*, *b*).
1 pupa was *light yellow-green* (1 *a*), with a tendency towards bone-colour in the ground (2).

2

(*c*) *In dark corner.*

The single pupa was discoloured, but was probably *light yellow-green* (1 *a*), with some tendency towards *grey* (2).

(13) YELLOW PAPER. (*a*) *In strong light.*

1 pupa was *dark yellow-green* (1 *b*).
3 pupæ were *yellow-green* (1), discoloured, but probably *light* (1 *a*), or intermediate between *light* and *dark* (1 *a*, *b*).
2 pupæ were *light yellow-green* (1 *a*), with some tendency towards *grey*.

6

(*b*) *Through glass.*

The single pupa was dead, and had entirely blackened.

(*c*) *On glass.*

The single pupa was discoloured, but was probably *yellow-green*, and certainly had not been highly pigmented.

(14) YELLOW-ORANGE LENO.

This label could not be found as distinct from the *yellow* (13) and *orange* (14); or I may have overlooked it. The results are certainly included in one or more of the sub-divisions of (13) or (14), inasmuch as the total number of the pupæ examined is 72,—the number given by Mr. Merrifield.

(15) ORANGE PAPER. (*a*) *In strong light.*

3 pupæ were *light yellow-green* (1 *a*).
1 pupa was *dark yellow-green* (1 *b*).
4

(*b*) *Through glass.*

The single pupa was dead or emerging, but appeared to have been intermediate between *dark* and *light grey* (2 *a*, *b*).

(*c*) *In shady corner.*

2 pupæ were *light yellow-green* (1 *a*).
1 pupa was *light grey* (2 *a*).
3

As Mr. Merrifield has stated on p. 381, the examination of these pupæ seems "clearly to prove the susceptibility of *P. machaon*." At the same time there was one unsatisfactory point in the evidence, viz. the extremely unhealthy condition of the pupæ. A large solitary ichneumon began to emerge from the pupæ in the autumn of 1898, soon after the date at which Mr. Merrifield showed them before this Society (October 5th, 1898). At intervals they continued to emerge until the early summer; and soon after my examination was made on May 2nd, 1899, they came out suddenly in large numbers. The ichneumons almost invariably gnawed a hole in the pupal wing, in order to escape. The whole batch produced very few butterflies.

It was unfortunate that press of work prevented me from comparing the pupæ until so late, when the discoloration of many of them had proceeded so far; but under any circumstances it was much to be desired that the susceptibility of undoubtedly healthy pupæ should be tested. Such a test I have fortunately been able to apply, and the result confirms Mr. Merrifield's conclusion in the most complete and convincing manner, as may be seen from the succeeding section.

5. Mr. C. V. A. Peel's Winter Pupæ of *Papilio machaon* described. (E. B. P.)

Through the kindness of Mr. Peel I have been able to compare a fine set of very healthy pupæ from Wicken Fen. The pupæ were in part attached to green reeds; in

part to the wood (somewhat darkened by age), and in part to the perforated zinc of two ordinary rectangular breeding-cages. It is clear that the two latter sets of pupæ had been formed from captured larvæ, while the set attached to reeds may have been, in part at least, found so attached in the open. Mr. Peel is not sure upon the point; but the fact that reeds, and reeds only, have been selected is in favour of this interpretation. The majority of the pupæ have now emerged successfully, and nearly all of those that remain are still healthy. Very few have died. The entire absence of parasites in this set of larvæ, as compared with their excessive abundance in Mr. Merrifield's continental individuals is of high interest, and suggests the same conclusion as that at which I arrived last year in breeding large numbers of Continental and English larvæ of *Vanessa urticæ*, viz. that the greater abundance of birds in this country may, by destroying parasites, compensate for their direct attacks on the species of Lepidoptera (see Report of British Association, 1898, Section D). I will now give the results of the examination which was made on May 3rd, 1899.

14 *pupæ attached to reeds.*

Thirteen pupæ were distinct *light yellow-green* (1 *a*). Of these 2 were fixed at some distance from each other on the same reed, while 10 were on separate reeds. Just below the thirteenth pupa was fixed the single exception a *dark grey* pupa (2 *b*).

19 *pupæ upon wood or zinc.*

In the breeding-cage which contained the reeds, one *dark grey* (2 *b*) pupa was lying loose upon the floor, and another of the same kind (2 *b*) was attached to the zinc.

In another breeding-cage 5 pupæ were attached to the zinc, in a curved line, near together. From above downwards their arrangement was—

2 pupæ intermediate between *dark* and *light grey* (2 *a*, *b*).
1 pupa *dark grey* (2 *b*).
1 ,, again intermediate (2 *a*, *b*).
1 ,, *light grey* (2 *a*).

Thus the central pupa was darkest, as though some influence had been exerted by the neighbouring larvæ or pupæ (as is so markedly the case in *Vanessa*).

Above these 5 pupæ, on the wooden roof, were 3 pupæ, two close together and one near them in the corner. All were *light grey* (2 *a*).

At the opposite end of the cage 3 pupæ were scattered over the zinc, one being intermediate between *dark* and *light grey* (2 *a*, *b*), two, *dark grey* (2 *b*).

On the wooden roof over them was a compact group of 5 pupæ, all intermediate between *dark* and *light grey* (2 *a*, *b*); while a single pupa loose on the floor was also intermediate (2 *a*, *b*).

Thus there was not a single exception among the pupæ on the zinc and wood. Furthermore those fixed to the latter were on the whole lighter than those fixed to the darker zinc. The singular completeness of the result is best shown in a tabular form as follows:—

	Yellow-green (1)		Grey (2)			
	Light (*a*)	Dark (*b*)	Light (*a*)	Intermediate.	Dark (*b*)	
Attached to green reeds	13	—	—		1	= 14
Attached to wood of cage	—	—	3	5	—	= 8
Lying loose on wooden floor (more in shade than roof and sides, and with dark débris scattered over it)	—	—	—	1	1	= 2
Attached to zinc	—	—	1	4	4	= 9
						33

It is unnecessary to examine these data further. It is obvious on an inspection of the above table that there is only a single exception to the complete susceptibility of the pupæ.

The much greater susceptibility of this set of pupæ as compared with Mr. Merrifield's considered as a whole, and with the few upon which I experimented in 1886 (Phil. Trans. 1887, *l. c.* p. 406), is probably due to their more healthy and vigorous condition, and perhaps in part to some of the results having been obtained under normal conditions (if it is admitted that most of the green pupæ were formed in the open). The larvæ are not gregarious, so there is no justification for assuming a family tendency towards susceptibility on the part of the set as a whole.

Local differences in susceptibility are of course possible, and an enquiry directed along this line might lead to results of high interest.

It is a great pleasure to me to see this species, upon which so much doubt has been thrown—in the first place in the discussion which followed Mr. T. W. Wood's communication to this Society in 1867 (Proc. pp. xcix—ci), and nineteen years later as the results of my experiments—now finally proved beyond doubt to be susceptible to the colours of its environment. This result, which we owe to Mr. Merrifield, is a further warning against the errors into which we are liable to be led by relying, as Mr. Bond did (in the 1867 discussion), upon a general impression gathered from a wide experience not specially directed towards the solution of the problem, as I did, upon an insufficient number of individuals subjected to experiment.

C.—EXPERIMENTS UPON THE PUPÆ OF *Papilio podalirius.* (CORA B. SANDERS and E. B. P.)

Five full-fed larvæ of this species were found by us in Switzerland, between Visp and Stalden, on July 22nd, 1898. They were all, except one, of the usual yellow-striped green form. The single exception was brownish-green with many red spots somewhat similar to those which occur upon certain forms of the larvæ of *Smerinthus ocellatus* and *S. populi.* It is possible that the darkened ground colour was due to changes preparatory to pupation, or perhaps to ill-health, as the larva died without pupating. Two of the larvæ were placed in a white muslin bag and offered green reeds together with the green twigs and leaves of the food-plant: three were placed in a black net bag, and provided with dark brown branches, as well as the food-plant. In a few days four of them pupated, one being fixed to the white muslin and three to the black net.

It was immediately seen that the latter were far darker than the former. A careful comparison was made on May 3rd, 1899.

The pupa which had been fixed to white muslin was a pale dull orange tint, especially dull over the wings. Of the other three which had been fixed to black net, one was also dull orange but of a distinctly darker shade,

while the remaining two were much darker still, being of a purplish-brown deepest in tint over the wings.

These small numbers are not sufficient to prove the susceptibility of this species; but they render such susceptibility probable. It is to be hoped that larger and more varied experiments will be made by those who have the opportunity of obtaining considerable numbers of the larvæ of *P. podalirius*.

D.—EXPERIMENTS UPON THE PUPÆ OF *Pieris napi*.

1. Experiments upon the Winter Pupæ of *Pieris napi*. (F. M.)

I exhibited to this Society on November 2nd, 1892 (Proceedings 1892, p. xxx), some pupæ of *P. napi* showing that the species was susceptible. In this present year I was experimenting on the species for other purposes, and determined to avail myself of the apparatus I had to provide for experiments on the coloration of pupæ of *P. machaon*. Mr. Harwood supplied me in the early part of August with a number of females captured in the vicinity of Colchester, and from them I obtained several hundred eggs on watercress, on which I fed the larvæ till about their last stage when that food was largely supplemented and finally replaced by cabbage. These when approaching pupation were exposed to the same colour influences as the *machaon* larvæ had been (substituting green cabbage-leaves for carrot-tops), and to the following in addition (16) planed deal in shade, (17) planed deal in light.

They seemed very unwilling to pupate on orange (except on the glass in front of the orange paper), so I shut up some in (18) a threefold yellow-orange leno cylindrical bag with single leno on the top, and orange paper outside two-thirds of the circumference, and here they were obliged to pupate.

In this species and in *P. brassicæ* my results are too numerous for me to show the whole in the Exhibition Case; but I have brought with me in glass-bottomed boxes, so that they can be seen, all the pupæ of both species which are not thus displayed (in the Exhibition Case), duly classified. There are in all about 340 pupæ of *P. napi*.

About 80 of the *napi* not in the general Exhibition Case are in a second Exhibition Case under the following circumstances. I had an old breeding-cage (somewhat resembling those previously described, but a little smaller) in two compartments with a glass roof over both; one of these was lined with black and had its glass top covered with double black tissue-paper, nearly opaque; the other was lined partly with orange paper, and partly with yellow paper or yellow-orange leno, and the glass top was covered with threefold orange leno, transmitting much orange light. Finding that a number pupated on the glass roof, I succeeded in detaching the plate of glass from the roof and mounting it for exhibition in a second case. It will be seen that on the black side there are 34 pupæ all bone-coloured and nearly all much spotted with dark; on the orange yellow side 46 pupæ, all green except 4 which are bone-coloured, though with a yellowish tinge, and nearly all the 46 practically unspotted.

I think this second Exhibition Case, in which the pupæ have arranged themselves, affords a very effective demonstration of the sensitiveness of this species.

The following section will contain a detailed statement of results by Prof. Poulton. Here it will be sufficient in reference to the first Exhibition Case to point to the contrast between the 10 on black paper or the 8 on black or dark sticks, all of which are dusky, with much black spotting, and the 19 on yellow or orange paper all of which, with one exception, are green, to the 12 on or near cabbage-leaves, many being attached to the glass bottle, most of which are green, and to the varying colour of those in darkness; the 8 on Dutch gold, the 7 on planed deal, the 8 on green and the 6 on white paper being nearly all bone-coloured, and most of them spotless or nearly so. These results clearly prove the high susceptibility of the pupa.

All the four species experimented on by me, in preparing to pupate vary in colour according to their surroundings, and I do not see any room to doubt, when the 16 pupæ of *machaon* on black paper or dark sticks are compared with the 4 on green carrot-tops, or when the 18 pupæ of *napi* on black paper or dark sticks are compared with the 12 which pupated on or near cabbage-leaves, that the adaptation must be in many cases protective.

2. Results of the above Experiments. (E. B. P.)

The pupæ of *Pieris napi* were compared on January 2nd, 1899, with a view to the construction of a standard table.

As compared with the allied *P. rapæ*, the dimorphism of the ground-colour is far more marked. Furthermore, the ground is almost invariably restricted to bone-colour or green in *P. napi*, whereas many different shades are common in *P. rapæ*. Even in pupæ with the darkest markings the bone-coloured ground is far less obscured by generally distributed pigment in *napi* than it is in *rapæ*. There is also in the former a marked dimorphism in the arrangement of the black markings, which show characteristic differences even when present in similar amounts in the two forms—bone-coloured and green. Thus the bone-coloured forms, however pale, almost always possess a distinct black patch (made up of two or three spots or short lines) in the centre of the fore wing. This character, which I call the "wing-mark," is either wanting or far less developed in the green forms, even when more richly pigmented in other parts of the surface.

Another difference is the far greater irritability of the pupæ of *P. napi*. A slight stimulus, such as light breath, would almost always cause active movements, when the more stolid pupæ of *P. rapæ* remained quiescent. This observation, which certainly held at the time the examination was made, may perhaps have been due to differences in the degree of development then reached by the two species.

The forms of the two pupæ are almost alike, and as each varies considerably, it is very difficult to distinguish them with certainty by this means; but the above-mentioned tests enabled me easily to pick out two pupæ of *P. rapæ*, which had found their place among Mr. Merrifield's numerous *napi*, having been accidentally introduced as larvæ in the food-plant.

The pupæ of *P. napi* are either *green* or have a *bone-coloured* ground with black markings and minute dots. The latter may be classified, according to the amount of pigment, as:—

(1) *Dark*, (2) *Intermediate*, (3) *Light*. In the *light* forms the pigment is so small in amount that the pupæ

are practically *bone-coloured* (3 *a*). The *green* pupæ are equally deficient in pigment and may be regarded as a dimorphic form of this degree (3 *b*). These relationships may be conveniently expressed as follows:—

1. DARK.
2. INTERMEDIATE.
3. LIGHT. (*a*) *Bone-coloured.*
   (*b*) *Green.*

(1) The *Dark* pupæ. The ground is bone-coloured. Black pigment is strongly developed on each side of the dorsal surface, forming a large sub-rectangular patch on each side of each abdominal segment, fusing into an irregular mass anteriorly, on each side of the thoracic region. The dorsal line is marked posteriorly by a distinct dot on each segment. Seven dots can be recognized, including one on the caudal spine. There is also a large pigment patch on each side of the mesothoracic keel and on each side of the anterior rostrum. Minute black points are scattered between the sub-dorsal pigment and that of the dorsal line.

On the sides, the principal development of pigment is on the wings, in which part of the venation is thus rendered conspicuous, while the outline of the hind margin of the future wing is marked by a distinct row of black dots. Near the centre of the wing is the "wing-mark" made up of two or more, generally three, intensely black patches —the largest inferior — apparently occupying spaces between the veins. Even in the darkest forms these patches are nearly always conspicuous from their superior blackness: they often tend to fuse, forming in many cases a single large patch.

The eye is strongly pigmented superiorly, but below and including the crescentic mark upon which alone of the entire pupal surface the facetted structure is developed (the pupal eye), it is devoid of pigment.

(2) The *Intermediate* pupæ. The ground is bone-coloured. These pupæ differ from the last, with which they are connected by transitional forms, in the lesser development of black pigment both dorsally and on the wings. As a rule the diminution is proportional throughout, but in certain cases the dorsal pigment may retain its full development.

The lesser amount of black pigment renders the intense

black patches in the centre of the wing especially distinct and sharp.

(3) The *Light* pupæ. (*a*) *Bone-coloured.* These also are perfectly transitional into the *Intermediate* pupæ. In pupæ of this degree the pigment is everywhere reduced, remaining strongest in the black patches in the centre of the wing, which become excessively conspicuous against the pale bone-coloured ground. In some of the most extreme cases these patches become much fainter, but a trace of them is probably always to be found. In other parts the pigment spots and patches are much smaller, and are often represented by minute dots: on the eye it is often absent altogether.

(3) The *Light* pupæ. (*b*) *Green.* Pigment is never highly developed upon the ground-colour of these pupæ. With very rare exceptions it does not exceed the amount present on the *light bone-coloured* pupæ (3 *a*). The *green* pupæ are far more transparent than the *bone-coloured*, and the palest are even more deficient in pigment than the palest of the *bone-coloured* forms. The most important difference in marking has already been mentioned, viz. the absence of the black patches in the centre of the wing (the "wing-mark") even when pigment is developed elsewhere as greatly as in a decidedly dark *bone-coloured* pupæ of the corresponding degree (3 *a*)—a pupa which would always possess distinct and prominent patches. Occasionally, however, faint traces of the marking may be detected, as minute dots, even in the palest *green* forms, and very rarely it is fully developed. All marked exceptions will be described below. In the centre of the wing the transparency is such that a considerable depth into the pupa can be seen, and the large tracheæ distinctly made out.

Before classifying Mr. Merrifield's numerous pupæ, I am tempted to suggest what I believe to be the meaning of this strange dimorphism in marking. The possible failure of my hypothesis would not, however, alter the validity of the observations which I have here recorded. Without attaching too great weight to it, I do not hesitate to suggest the hypothesis, thinking it possible that observation and thought may be stimulated by its means.

I have just alluded to the great transparency of the *green* pupæ (3 *b*), and have stated that this is especially marked in the centre of the wing, viz. in the exact position of the dark mark on the *bone-coloured* pupæ (3 *a*).

These latter are also, though less transparent than the green, chiefly so in the same area.

The *green* pupæ resemble green leaves and stems, and Mr. Merrifield's experiments show that they are produced by such surroundings: the *bone-coloured* pupæ resemble, and are produced by, such surfaces as bark, wood, or stone.

Now the transparency is no hindrance to the concealment of the former: it is rather an advantage. But to the latter it is a distinct hindrance and, when once seen, immediately betrays the fact that the pupa is not the opaque object to which it presents so strong a superficial resemblance. I believe that this is the reason why this particular area is so invariably covered up by dark patches of pigment in the pale bone-coloured pupæ of this species. I believe that the persistence of this particular mark when the other pigment spots and masses are disappearing in the palest pupæ, is due to the operation of natural selection.

The experiments and observations Miss Cora B. Sanders and I were able to conduct, in the summer of last year, prove that pupæ (in this case of *Vanessa urticæ*) are subject to a tremendous struggle for life: they also strongly indicate that the enemies are guided by their sight in hunting for them. Hence it appears to me that there is nothing improbable about the suggestion that this dark patch covering the transparent area may have been retained by natural selection in certain forms, because transparency would be a danger, may have been dismissed in certain others, because transparency would be an advantage.

The pupæ were compared and tabulated on Dec. 22nd, 1898, and on the following dates in 1899—Jan. 6th, 7th, 9th, and 28th. Nearly all of them were extremely healthy, and showed the effects of the conditions in a remarkable manner. As these are the first complete and detailed experiments which have been conducted upon this sensitive species, and the material was in such excellent condition, the comparison was carried out with the utmost care, and numerous details were recorded which are included in the tabular statement below. The order is that in which the pupæ of *P. machaon* were considered so far as the conditions were the same. The conditions which were different are placed at the end.

It is to be observed that the *light-green* forms (3 *b*)

Experiments.		Degrees of Pupal Colour.					Remarks.
		Dark (1)	Intermediate (2)	Light (3) Bone-coloured (*a*)	Light (3) Green (*b*)	Totals	
1. Black.		6	4			10	Three of the (2)s very dark.
2. Black compartment (pupæ fixed to black).		15	1	1		17	(2) Very dark: (3 *a*) very light. Also two dead pupæ which were probably (1) or (1) and (2).
3. Miscellaneous black compartment.			1			1	
4. Black through glass (in shade).				1		1	Very pale pupa.
5. Black compartment, through glass.			2	1		3	The (3 *a*) darkish.
6. Black half of a sheet of glass forming roof. The other half was orange-yellow and will be described below. All pupæ were on black "through glass." The whole sheet was exhibited to this Society. (See page 391.)	Anterior group mostly close to clear glass front.	5	6	6		17	Pupæ mostly fixed parallel to glass front: the heads of only five pointed towards light, and only two of these pointed directly (the body line at right angles to glass front).
	Group half-way between back and front, and towards inner side (viz. nearest orange).	1	1			2	One pupa pointing towards light; one had become loose.
	Group in posterior inner corner of roof.	1	1			2	Another pupa had died and is not classified: another was accidentally mixed with next group and is there classified. All four towards light (direct).
	Group in posterior outer corner and extending along outer side of roof.	10	2			12	Including one pupa from last-named group. All pupæ towards light and all direct except one.
7. Black compartment on or near front glass		3	7	4		14	One (3 *a*) rather dark with an indistinct wing-patch; another much lighter with a faint one. In addition, an extraordinary intermediate form not tabulated—a pale green ground with the pigment of a (2).

Experiments.	Degrees of Pupal Colour.					Remarks.
	Dark (1)	Intermediate (2)	Light (3)		Totals	
			Bone-coloured (*a*)	Green (*b*)		
8. Dark sticks.	2	4	1		7	Another pupa had died. The (3 *a*) was dark.
9. Dark sticks: pupæ fixed to bottle.		1		1	2	The (3 *b*) very pale and pigmentless.
10. Dirty white paint.	9	15	5	2	31	Two had died and are unclassified. It is certain that neither was green. One pupa was withdrawn as a *P. rapæ*. One (3 *b*) dark but no wing-mark to be detected.
11. Glass of old eage.		3	4		7	All light for their degrees exeept one (3 *a*).
12. Darkness.		1		6	7	Of the (3 *b*)s two are deep green with mueh pigment for this degree, two similar with little pigment, two pale and almost pigmentless.
13. Dead reeds.		4	4		8	Wing-mark faint in three (3 *a*); two of them dark for this degree.
14. Dead reeds; pupæ on glass.			1	1	2	(3 *b*) deep green with little pigment.
15. Dull green reeds.		3	7	1	11	(3 *b*) pigment very dark, equal to darkest (3) or even light (2): wing-mark small but dark. One (3 *a*) with very slight wing-mark. The (2)s light.
16. Dull green reeds; pupæ on glass.			3		3	Another pupa dead. Wing-mark indistinet in one.
17. Oat-straw.			3	2	5	(3 *a*) wing-mark indistinet in two. (3 *b*) one pale, one deep green, both with very little pigment.
18. Oat-straw; pupæ on bottle.			2		2	Pupæ with little pigment and wing-marks indistinet.

Experiments.	Degrees of Pupal Colour.					Remarks.
	Dark (1)	Intermediate (2)	Light (3) Bone-coloured (*a*)	Light (3) Green (*b*)	Totals	
19. Dutch "gold" on sticks.			8		8	Six pupæ with very little pigment. Wing-mark very faint in two, invisible in one.
20. Dutch "gold" through glass.				1	1	Deep green; little pigment.
21. Dutch "gold" on glass.			1		1	Almost pigmentless except for very distinct, dark wing-mark.
22. Green paper spills.			7		7	Another pupa dead. Five pupæ with very little pigment, and wing-mark indistinct, or even invisible.
23. Green paper, through glass.			1		1	Very little pigment.
24. Green paper, on glass.				1	1	Very little pigment; deep green.
25. Green cabbage-leaves; pupæ chiefly on bottle.			4	6	10	Another pupa dead: (3*a*)s very light, but with wing-mark conspicuous. (3 *b*)s pale green except one, all with little pigment.
26. Green cabbage-leaves; pupa on white muslin.			1		1	Very pale pupa with faintly transparent yellowish appearance.
27. White paper.			6		6	Very little pigment; wing-mark distinct and dark on three, indistinct on one, hardly visible on two.
28. White paper, through glass.			1		1	Almost pigmentless.
29. Yellow paper.			1	7	8	Nearly all pupæ almost pigmentless. The (3 *a*) transparent yellowish and really transitional to (3 *b*). Of the latter, two pale, two intermediate, and three deep green.

EXPERIMENTS.	Degrees of Pupal Colour.					Remarks.
	Dark (1)	Intermediate (2)	Light (3) Bone-coloured (*a*)	Light (3) Green (*b*)	Totals	
30. Yellow paper, through glass.			1	1	2	The (3 *a*) is transparent greenish-white, and transitional to (3 *b*). The latter deep green with much pigment for this degree.
31. Yellow paper, on glass.			1		1	Like the (3 *a*) described above and, like it, very pale and pigmentless.
32. Orange leno bag.				11	11	Two pale, nine deep green. One of former fixed to a leaf. Seven with very little pigment and the others not very dark.
33. Orange-yellow compartment; miscellaneous pupæ.				8	8	Another pupa dead. One pale, two intermediate, five deep green. All very pigmentless except three of latter (not very dark), and one remarkable deep green form with the pigment of a (2) and a small distinct wing-mark; also present on two of the last-mentioned set of three.
34. Orange compartment, near leno and dirty white paint.			1	3	4	(3 *a*) very pale and pigmentless with *no* wing-mark. (3 *b*) one pale, two deep green, all dark pigmented; faint trace of wing-mark on one.
35. Orange yellow half of glass roof. The pupæ on the — Anterior scattered group, many close to clear glass front.			1	13	14	Five pupæ parallel to glass front (four close to it), one with tail, seven with head pointing directly to light: one with head to light, but body line not direct (viz. forming angle of about 45° with front). (3 *a*) very pale, transparent, and pigmentless, much more so than any on the black side of same sheet. One (3 *b*) pale

Experiments.		Degrees of Pupal Colour. Dark (1)	Intermediate (2)	Light (3) Bone-coloured (a)	Light (3) Green (b)	Totals	Remarks.
other (black) half have already been tabulated (6) on page 396. All pupæ were on orange-yellow "through glass."							yellowish-green, and really transitional to (3 *a*). It and five others almost pigmentless, six with very little pigment, and one with much, like a dark (3 *a*) and yet hardly a trace of wing-mark. Twelve of the (3 *b*) distinct green ground.
	Compact group in the outer side of the middle part of roof (viz. away from the black).			1	7	8	Heads of all pupæ directly point to light. The (3 *a*) very pale, but more pigmented than any green (3 *b*) in this group and with traces of wing-mark. (3 *b*) all distinct green and very little pigment.
	Group in the inner side of the middle part of roof (towards the black).			1	8	9	Another pupa dead. All heads pointed directly to light. (3 *a*) with very little pigment. Seven (3 *b*) similar, and one darker, but no trace of wing-mark. All (3 *b*) distinct green.
	Elongated group along outer side of posterior part of roof.				13	13	All directly faced light except one parallel with front and two reversed (tails directly pointing to light). All distinct green, and, except three, with very little pigment.
	Inner side of posterior part of roof.				1	1	Distinct green, very little pigment. Directly faced light.
36. Orange, through glass.					3	3	Another pupa dead. One pale, two deep green; all very pigmentless.

Experiments.	Degrees of Pupal Colour. Dark (1)	Intermediate (2)	Light (3) Bone-coloured (a)	Green (b)	Totals	Remarks.
37. Orange compartment; leno through glass.			2	3	5	(3 *a*) very pale and pigmentless. (3 *b*) one pale, two deep green, one of latter with medium pigment, other two very pigmentless.
38. Orange-yellow compartment, on or near front glass.		1	19	6	26	Another pupa dead. (2) very pale. (3 *a*) ten pupæ very pale and pigmentless with wing-mark minute, faint, or absent; of these two are greenish and transitional to (3 *b*). Six are light with wing-mark prominent. Three rather darker, but only average for this degree. (3 *b*) one pupa pale, five deep green. Two almost pigmentless (including pale one): four rather dark for this degree and minute wing-mark on two.
39. Planed deal, in light.		1	3		4	(2) very pale. Very little pigment on (3 *a*)s and very faint wing-mark on one: prominent on others.
40. Planed deal, in shade.			5		5	Four with very little pigment, but wing-mark distinct: one typical.
41. Planed deal, on glass lid.			1		1	Very pale and pigmentless, but wing-mark distinct.

which presented any trace of a "wing-mark" are specially so described: when no reference is made to this character it may be assumed that it was absent in (3 *b*)s, normal in (3 *a*)s.

I will now briefly summarise the results obtained with this highly interesting and sensitive pupa. For the sake of brevity (3 *a*)s are called *light* pupæ; (3 *b*)s *green* pupæ.

Black (1 to 7). The very powerful effect of black in

producing the darkest pupæ is very clearly seen. The black paper did not act quite as strongly through the thickness of glass (4, 5, 6) as when the pupæ were in direct contact with it. When the pupæ were upon the glass window at a varying distance from the black paper, the effects were much less marked (7). Black in shade (4) produced an *intermediate* pupa, but the parts of the roof of case (6) which were farthest removed from the light produced pupæ which were rather *darker* than those nearer to it.

Dark sticks (8) produced as great an effect as black, but little or no influence was exerted at a distance (9).

Dirty white paint (10) gave rise to a great variety of pupæ, all forms being represented among the thirty-one forms tabulated, the *dark* and *intermediate* degrees (1) and (2) strongly predominating.

Clear glass (11) produced *intermediate* and *light* pupæ, while in *Darkness* (12) they were strongly *green*—six out of seven being (3 *b*). This result is so remarkable and extreme an effect of darkness that further experiments are to be desired. It is probably to be explained by the strong normal tendency of this species to produce *green* forms in the absence of any effective stimulus (see 9, 14, 24, in support of this: the pupæ on the glass removed from the stimulus are greener than those subjected to it).

Dead reeds (13) produced *intermediate* and *light* pupæ; at a distance (14) *light* and *green* ones were formed.

Dull green reeds (15) produced chiefly *light* pupæ (3 *a*) with some *intermediate* (2) and a single *green* one (3 *b*); on the glass they were all *light* (16).

Oat-straw (17) caused the pupæ to become *light* (3 *a*) and *green* (3 *b*), while at a distance they were *light* (18).

Dutch "gold" (19, 20, 21) tended strongly towards *light* pupæ (3 *a*), the only exception being in the case of a *green* pupa (3 *b*) formed when the gilt surface was the other side of glass (20). At a distance (21) the single pupa was similar to those fixed on the gilt.

Green paper (22, 23, 24) produced almost exclusively *light* pupæ (3 *a*), the action through glass (23) being similar to that of the coloured surface itself. At a distance a single *green* pupa (3 *b*) was formed.

Green cabbage-leaves (25, 26) on the other hand produced far more *green* than *light* pupæ, affording a most interesting comparison with the artificial colour. On this point see the Appendix in which the constitution of the light

reflected from the latter is described. The pupa on white muslin (26) was *light* (3 *a*), and probably affected by this surface rather than the leaves.

White paper (27, 28) is of great interest, invariably producing *light* pupæ (1 *a*); the influence through glass (28) being the same as that exerted directly (27). We see in this and in the pupæ produced by Dutch "gold" (19—21) a great advance in the susceptibility of these pupæ over those of the *Vanessidæ*. Thus the highly sensitive pupa of *V. io* is influenced in the same direction by bright green (such as those of nature), yellow and orange as it is by golden metallic surfaces and by white. These all alike tend to produce brilliant green pupæ with a golden sheen over much of the surface. And yet such pupæ would only be concealed on the bright green backgrounds. The pupa of *P. napi* is similarly influenced by bright green, yellow, and orange, but is quite differently affected by white and gilt. The pupæ in the latter case are *light bone-coloured* (3 *a*), and certainly much more effectually concealed on a white surface than if they were green. Traces of the same kind of sensitiveness at a much lower level of development are rendered probable in *Papilio machaon* from the results already recorded, and will be seen to exist in *Pieris brassicæ* and *P. rapæ*, in the formation upon a white background of intermediate, grey, and pale forms rather than green ones. The similar effects of bright green, yellow, and orange are certainly to be explained as they have been in many other species, both larvæ and pupæ, by the fact that all these colours reflect a high proportion of the effective rays, viz. the yellow and orange. This will be proved in the case of *P. napi* by the results of the spectroscopic examination of the backgrounds which were made use of (see Appendix).

Yellow paper (29—31). Produced only the *light* (3 *a*) and *green* pupæ (3 *b*), the latter strongly predominating. The influence through glass (30) and at a distance (31) was less strong in the direction of green, although the number of pupæ was too small to carry much weight.

Orange leno and paper, in some cases combined with yellow (32—38), were even more powerful than the yellow in producing *green* pupæ (3 *b*); in fact if we consider those experiments only in which the pupæ were directly placed on the backgrounds or were only separated by the thickness of the glass (32, 33, 35, 36, 37), no less than sixty-

seven *green* pupæ (3 *b*) were formed as against five *light* ones (3 *a*). The influence through glass (35, 36, 37) was undiminished; but that at a distance (34, 38) was immensely reduced, a single *intermediate* pupæ (2), a large number of *light* (3 *a*), and only a few *green* (3 *b*) being produced.

Planed deal (39—41) seemed to produce effects comparable to those of white, viz. that form of pupa out of the various possible degrees, which harmonized best with the background, viz. *light* (3 *a*), a single *intermediate* one (2) also appearing. No appreciable difference is to be noted between the effects in strong light (39), shade (40) and at a distance (41).

Looking at these experiments as a whole, the much smaller effect produced by the coloured backgrounds upon the pupæ "on the glass," viz. at a more or less distance from the effective stimulus, harmonizes well with the results of previous investigation.

The strong tendency of the pupæ, or rather the larvæ, to face the light directly is well shown in the results of Experiments (6) and (35) where the positions are recorded. The *great* majority of the exceptions were due to the larva placing itself parallel and in close proximity to the clear glass front. A similar tendency to seek the angles between a horizontal and vertical surface probably in part explains the fact that so high a proportion *directly* faced the light, the body line having been drawn into parallelism and often into contact with the sides. In these experiments only one pupa was parallel with and close to the back, but I have noticed very many pupæ of *Picris brassicæ* in shallower breeding-cases, in this position. The few complete exceptions in (6) and (35) in which the head pointed directly away from the light are enough to show that susceptibility is unaffected by orientation.

Mr. Merrifield is to be congratulated in having proved the high degree of sensitiveness possessed by this pupa. While the susceptibility is as great as that of any other species, even of the highly sensitive *Vanessa io*, the range of controllable modification is probably wider than in any other as yet investigated in sufficient numbers. This is shown by the production not only of *green* and *dark* forms, but of *pale* and *grey* pupæ upon such backgrounds as white paper and planed deal. At the same time the range is not nearly so great as that of the larva of *Amphidasis betularia*, which can produce on appropriate dark

surfaces many distinct shades ranging through *black*, *brown*, and *grey*; and also on the provision of the appropriate stimuli can become *white* or *green* (Trans. Ent. Soc. 1892, *l. c.*).

The reactions of the pupæ of *Pieris napi* to the colours employed agree well with the observations recorded in the case of other susceptible pupæ if allowance be made for the wider range of controllable modification.

E.—EXPERIMENTS UPON THE PUPÆ OF *Pieris brassicæ.*

1. EXPERIMENTS UPON THE WINTER PUPÆ OF *Pieris brassicæ.* (F. M.)

I took advantage of the pestilential abundance of the larvæ of this species to experiment on them and I exhibit samples of the results, which will be described so far as necessary in the following section. It is the less necessary to refer to them at any length, because the species has been so fully experimented on by Prof. Poulton as described in the papers before referred to, and as will appear later in this memoir, also during the present year (1898). But I would call attention to one feature, that has been carried perhaps a little further than had been done before, in my experiments on this species and the next referred to, *P. rapæ.* It seemed a fair inference both from Prof. Poulton's paper and from my personal observation of the experiments with darkness on the other two species, that the positive application by reflection or otherwise of some decided colour (including black and white among colours) was necessary to affect the colour of the pupæ in a marked degree. Accordingly I tried the experiment of surrounding some pupæ with clear glass away from all near reflecting objects. For this purpose I placed the full-fed larvæ in clear glass cylinders covered by clear glass and resting on a clear glass sheet several inches above the table, so that light reached them all round. They were placed on a table near the window. It will be observed that in the case both of this species and the next, the pupæ of the larvæ thus exposed to uncoloured light on all sides, rather closely resemble those in darkness, the former being somewhat darker than the later. In the case of *P. napi* darkness produced much variety of colour: of seven all but one are green but of somewhat varying tint, and the one bone-coloured and two of the green ones are much spotted with dark.

I found this species very troublesome as to the place of its pupation. In no one case did I succeed in getting it to pupate on a stick whatever its colour, and it had a way of pupating on the clear glass in front of the cylinder or bottle. To circumvent it I procured some white photographic trays, some of which I covered with orange glass, and others with deep green glass, while one was lined with black paper and covered with clear glass, and another, left white, was covered with clear glass. The space left between the bottom of the tray and the glass covering varied from about $\frac{1}{4}$ inch to $\frac{3}{8}$ inch or a trifle more, and in some cases it will be seen the pupa bears marks of squeezing. These instances are indicated by the word "screen," in the case of trays thus provided with screens of coloured glass, "tray" where the covering was clear glass.

The whole of the pupæ obtained (about 80) are displayed, part in the Exhibition Case, and part in the glass-topped boxes.

2. Results of the above Experiments. (E. B. P.)

The pupæ of *P. brassicæ* were compared May 3rd and May 6th, 1899, the results being shown in the following table (see pp. 407, 408). The degrees of pupal colour are the same as those suggested and fully described in Phil. Trans. 1887 (*l. c.* pp. 409, 410). The letters *g. o. w. y.* indicate the faint greyish *green, orange, yellow,* or *white* tint of the pupæ in the darker degrees. The tint is however usually very faint, being greatly obscured by the dark pigment (see also Trans. Ent. Soc. London, 1892, p. 439).

These results afford a very useful confirmation of those which have been previously obtained. Thus the *black* (1, 2, 3) produced uniformly *dark* pupæ, the effect being as strong when the dark surface was behind glass (3) as when it formed the surface to which the pupa was attached (1, 2). The black surroundings also produced a considerable effect upon pupæ which were attached to the clear glass at some distance (4).

Darkness (5) produced far more *intermediate* pupæ, although still upon the *dark* side of *intermediate.* As Mr. Merrifield has suggested, this result is to be compared in an interesting manner with that of *clear glass* (28). It is probable that in these two cases we witness the results of pupal tendencies undirected by any effective stimulus.

EXPERIMENTS.	DEGREES OF PUPAL COLOURS. (1) Darkest. (α)	Intermediate. (β)	Light. (γ)	Whitish Yellow. (2)	Green. (3)	Remarks.
1. Black.	1 *o*	3 *g*				The darker pupa dead.
2. Black tray.	1 *w*	2 *g,y*				Also one dead and one emerged: both probably (1 β).
3. Black, through glass.	1 *g*	2 *g*				
4. Black, on glass		4 *w,y* *g,g*				Also one dead, probably a (1 β).
5. Darkness.		2 *g,o*	3 *g,w,y*			Probably one more pupa accidentally transferred to those on clear glass.
6. Green paper.		1 *y*	1 *y*	2	1	
7. Green gauze.				1	1	
8. Green, through glass.			2 *w,g*	3	1	
9. Green screen.				1	1	Also one dead, probably (2); and one emerged; not darker than (1 γ). The (3) was a peculiar greyish-green.
10. Green, on glass.			3 *g,g,w*	3	1	Also one dead; a (1 γ), or darker.
11. Cabbage leaves.			2 *g*	1	1	Also one dead, evidently a (2) or (3).
12. White.		1 *w*		1		
13. White paper (cylinder).		1 *y*				
14. White paper.		2 *w,g*	1 *y*			Also one dead, but certainly a (1 β).
15. White calico.		2 *y,w*	1 *w*			
16. White tray.		1 *w*			1	
17. White, on glass.			2 *y*	1		

Experiments.	Degrees of Pupal Colours. (1) Darkest. (α)	Intermediate. (β)	Light. (γ)	Whitish Yellow. (2)	Green. (3)	Remarks.
18. Yellow paper.					2	Also one dead.
19. Yellow, in shade.		3 o,g,g				Also one dead, but probably a (1 β).
20. Yellow, through glass.			2 w,y			
21. Yellow, on glass.				1		
22. Yellow compartment, on glass with patch of white paper behind.					1	
23. Orange leno.		1 w	1 g			Also one dead or emerging, about a (1 β).
24. Orange.			1 w	1	1	
25. Orange, through glass.					1	
26. Orange screen.				4		
27. Orange on glass.				1	3	One (3), a curious greyish form.
28. Clear glass.		6				Also one dead, probably a (2) or (3). The (1 β)s are, one greyish-orange, four green, one white. Probably one pupa belongs to the group in darkness.

Green paper, *gauze* and *cabbage-leaves* (6, 7, 8, 10, 11) caused the appearance of far lighter pupæ, the majority being the *whitish-yellow* degree (2). Here too the influence through glass (8) was as strong as in the other experiments (6, 7). The few pupæ subjected to light through *green glass* (9) were of the two lightest and greenest degrees, thus confirming the effects described in Trans. Ent. Soc. Lond. 1892 (pp. 429—432, 446, 466—

468), and ascribed to the greater concentration of the effective rays. The stimulus produced a strong effect at a distance (10). The powerful effect of a natural green environment (11) is of great interest.

The experiment with *white* (12—17) was especially useful, as this environment had been almost omitted from the previous investigation of this species. It is at once seen that the effect is to produce *intermediate* pupæ, inclining towards the *dark* side. In this, the results differ widely from those obtained with *Vanessa urticæ* and *V. io* in which white surroundings produced strong effects in the direction of the golden and green pupæ respectively. There is great uniformity in the results obtained by the different white backgrounds, and the action at some distance (17) was clear. It will be found that my own experiments (43 to 48) in 1898 (see pages 415, 416) lead to the same conclusions as those which result from Mr. Merrifield's.

Yellow surroundings (18 to 22) produced the usual strong effects in the direction of the palest, greenest pupæ, the influence being much reduced in shade (19), and also reduced when acting through glass (20). An influence at some distance was probably exerted in (22).

Orange surroundings (23 to 27), for the most part, produced the same effect as the yellow, the orange leno (23) being an exception. Influence was strong through glass (25), and at some distance (27). The orange screen (26) produced considerable effects, in accordance with the principles already explained (Trans. Ent. Soc. Lond. 1892, *l. c.*); although an even stronger result might have been expected.

This account of the results should be read in relation to the Appendix, in which the colours reflected from the various backgrounds are analyzed.

3. Experiments upon the Winter Pupæ of *Pieris brassicæ*. (E. B. P.)

I also took advantage of the immense abundance of this species to repeat some of the experiments made in previous years upon insufficient numbers. The larvæ in part came from St. Helens, Isle of Wight (experiments 5, 6, 37, 38, 39, 40), partly from St. Helens and near Reading (13, 41, 42), and partly from St. Helens and near Oxford (remaining experiments, including those with conflicting colours,

and excepting Nos. 4 and 12). They were collected by Miss Cora B. Sanders (St. Helens and Reading), by Mr. W. Holland (Oxford), Mr. A. H. Hamm (Oxford), and by myself (St. Helens). Experiments 13, 41, and 42 were conducted by Miss Sanders; 5, 6, 37, 38, 39, and 40 by me, and the remainder by Mr. Holland and Mr. Hamm. I wish to express my warm thanks for all the large amount of kind help I have received.

The conditions of experiment are sufficiently shown in the following tabular statement (see pp. 411—416), the constitution of the reflected light being given in the Appendix.

The pupæ were examined on May 6, 7, 8, 9, 10 and 11, 1899, when several of them had emerged or were emerging. All these, however, are indicated below, and nearly all could be tabulated with considerable accuracy.

The positions of the pupæ in relation to the receptacles employed and to the light were noted in a large number of examples, with the following results. Thirty-six pupæ were fixed to the roof (or in the angle between it and the back), with a direction parallel with the front (generally clear glass) and back; 25 were fixed to the front, back, or sides in a vertical position with the head uppermost (including a few with the head downwards—cases in which pupation certainly occurred during a temporary reversal of the position of the receptacle); 41 were fixed, almost invariably to the roof, with the head pointing directly towards the light, viz. with the line of the body at right angles to the front (generally clear glass); 11, otherwise similarly placed to the last, had their heads pointing directly away from the light; 15, otherwise similar, had their heads obliquely directed towards the light; 10 their heads obliquely directed away from it. It is therefore clear that there is, upon the whole, a tendency to direct the head towards the light, although the tendency is not nearly so strongly marked as in *P. napi*. There was no appreciable difference in the colour according as the head pointed towards or away from the light.

Reviewing the results of the tabulated experiments, the effect of black (1 to 9) is, with certain exceptions, similar to that which has been obtained before, and also to Mr. Merrifield's investigations carried on simultaneously. These exceptions are the very dark pupæ obtained in almost complete darkness (8), and the very unusual lightness of some of those in dim light (6, 7).

Experiments.		(1) Dark. (α)	(1) Intermediate. (β)	(1) Light. (γ)	Whitish-Yellow. (2)	Green. (3)	Remarks.
1. Black lined cylinder (wide and low, placed on side with clear glass front).		1					On roof near and parallel with glass front. Emerging.
2. Black lined cylinder (very similar to last).		3	1 *y*				Similar position to above; together with three other dead pupæ (unclassified). Two of the (1 α) greenish, the other emerged.
3. Smallish black cylinder (intermediate in size between 7 and 24, same arrangement) with two compartments, moderate illumination.				1 *g*			Pupa on black paper roof of upper compartment.
4. Tarred fence near Oxford.							Two pupæ found April 2, 1899, by A. H. Hamm. They were very dark, probably (1 β) or even (1 α).
5. Black-lined box 25·5 c.m. by 21 c.m. in section; 9·5 c.m. deep. Window 11 c.m. by 13·5 c.m. covered with black net. Box placed on one short side. Illumination moderate.	Attached to roof.		4 *g, g, w* ?	4 *g, o, o, y*			One (1 β) emerging. Also seven dead, four probably (1 γ), two (1 β) or (1 γ), and one uncertain. Also one emerged, and was a (1 γ). Pupæ chiefly in two crowds of seven to R., and five to L. of roof. The heads were nearly as often away from light as towards it; often oblique, and often parallel with back or front.
	Loose on floor.			1 *g*			Also one dead; it had been a (1 γ).
6. Box very similar to last, but window a little smaller.	Attached to roof.		4 *w, w, o, o*	1 *y*	2	1	Also six dead; 1 = (1 β), 4 = (1 β) or (1 γ), and 1 = (1 γ). Also two emerging, a (1 γ) and a (1 γ) or (2). A group of four at back and of ten on left side, heads of those (six) not parallel with back nearly always turned to light.
	Attached to black net window.		1 *y*				Also three dead on the sides of box; all (1 γ) or rather lighter or darker than this. Also one dead, loose on floor—a (1 β) or (1 γ).

Experiments.	(1) Dark. (α)	Inter-mediate. (β)	Light. (γ)	Whitish-Yellow. (2)	Green. (3)	Remarks.
7. Small black compartmented cylinder, in deep shade. The cylinder about 10 c.m. high by 6 c.m. in diameter. A black paper partition divided the cylinder into two chambers illuminated by a narrow window 2· to 3·5 c.m. wide.					1	Pupa from a single larva put in lower compartment. Rather more pigment than usual, but deep green ground. Pupa fixed vertically, head upwards, at top of side opposite window, but latter closed above and the roof very convex below, so that larva had been in deep shade.
8. Black cylinder in almost complete darkness: 16 c.m. diameter by 10 c.m. deep.	1 *o*	3 *g*				All pupæ isolated. All (1 β) very dark and two of them nearly (1 α).
9. Black-lined (3 sides) rectangular glass case (18 c.m. square by 28 c.m. high) with perforated zinc roof.	1 *o*, *g*	3 *o*, *g* ?				Four pupæ isolated on roof; the (1 α) *g*, on clear glass window, just below black binding and zinc at top, and near black paper of side.
10. Perforated zinc roof of yellow-lined (three sides) rectangular glass case (28 c.m. square by 38·5 c.m. high).		4 *o*, *o*, *g*, *g*	1 *o*			Also one emerged; was a (1 β) or (1 γ). All tabulated pupæ on roof in groups of two and three.
11. Similar zinc roof of similar white-lined (3 sides) case (23 c.m. square, by 33 c.m. high).	1 *w*	2 *o*				Also one dead, probably a (1 γ) or (2). All pupæ isolated on roof.
12. Brown paper.		1				Found in O. U. Museum by A. Robinson. Probably an escape from my cases. Imago had emerged, but pupa so dark it may have been even a (1 α).
13. Salmon-pink box in strong light (24 c.m. by 13·5 c.m. in section in front).					1	All sides and roof sloped inwards to a back only 10 c.m. by 18 c.m. This caused a very strong illumination.
14. Orange paper-lined cylinder (22 c.m. diameter, 10.2 c.m. deep). Placed on side with clear glass front.			1		2	Also one emerged, a (2) or (3). The (1 γ) bright yellowish green. All pupæ on roof.

Experiments.		(1) Dark. (α)	Intermediate. (β)	Light. (γ)	Whitish-Yellow. (2)	Green. (3)	Remarks.
15. Orange-lined cylinder (27 c.m. diam. 8 c.m. deep) arranged as the last.				1 *g*		2	One (3) on glass front, three-quarters up. Others on roof.
16. Orange-lined cylinder (30·5 c.m. diam. 9·8 c.m. deep). Arranged as the last.						4	Also one emerged, evidently a (3). One of the (3)s had the pigment of a (1 γ) but bright green ground of a (3). All pupæ on roof.
Four-compartmented orange-lined box. Each compartment 10 c.m. square, 6·4 c.m. deep. Box placed on side with clear glass front.	17. Compartment I.					3	Two on roof, one on floor. The box had clearly been turned over for a time, so that floor became roof.
	18. Compartment II.				1	2	All on roof.
	19. Compartment III.			1 *g*		2	Also one emerging—a (2) or (3). Two on roof, one on angle of roof and side, one head *downwards* on side; clearly due to box having been turned over.
	20. Compartment IV.						One pupa emerging, but probably a (1 γ); one dead, but was a (2) or (3). Both on roof.
Compartments 4·5 c.m. by 3.75 c.m. in section, 5·3 c.m. deep.	21. Compartment H, orange-lined.				1		On back, close under roof.
	22. Compartment L, orange-lined.					1	In angle between roof and back.
23. Lower compartment of small orange-lined cylinder, similar to 7.						1	In angle between roof and side.
24. Lower compartment of large orange-lined cylinder (8 c.m. diam. by 18 c.m. high, with window 3·4 c.m. wide) arranged similarly to 7.						1	Position of pupa clear although emergence had occurred. On roof, close to side.

Experiments.		(1) Dark. (α)	(1) Intermediate. (β)	(1) Light. (γ)	Whitish Yellow. (2)	Green. (3)	Remarks.
25. Orange-lined rectangular glass case (30·5 c.m. square, 41 c.m. deep) on side with clear glass window.			1 *g*	1 *y*	3	3	Also two dead, a (2) and a (2) or (3). One of the (2)s tabulated was loose on floor: all the rest of the pupæ on roof. The darkest pupæ in dim illumination.
Eight-compartmented box. Compartments 12—13 c.m. by 14 c.m. in section, 8·4 c.m. deep. Placed on side with clear glass front.	26. Compartment E, orange-lined.					2	On roof.
	27. Compartment F, orange-lined.					3	Two on roof, one on side. Also one dead on side and one on roof; both probably (3) or one perhaps (2).
	28. Compartment G, orange-lined.				2	1	All on roof; one emerged and one emerging, but position seemed certain.
	29. Compartment H, orange-lined.			1 *o*	1		Also one emerged, almost certainly a (2). All on roof.
In same box as 21 and 22. A wider and E narrower box than H and L.	30. Compartment A, yellow-lined.					1	Pupa loose on floor.
	31. Compartment E, yellow-lined.				.	..	One pupa dead on roof, a (2) or (3).
32. Upper compartment of large yellow-lined cylinder Similar to 24.					1		Pupa on side just below roof.
Eight-compartmented box. These compartments similar to other four, viz. 26 to 29.	33. Compartment A, yellow-lined.					1	In back corner of roof.
	34. Compart. ment B, yellow-lined.				2		One on roof, one on back: latter with the green ground of a (3).
	35. Compartment C, yellow-lined.				1	1	Pupæ isolated on roof.
	36. Compartment D, yellow-lined.			4 *o, g, g, y*		1	Four crowded, one isolated (1 γ) *y* on roof.

Experiments.	(1) Dark. (α)	Intermediate. (β)	Light. (γ)	Whitish-Yellow. (2)	Green. (3)	Remarks.
37. Yellow-lined box placed on side, 20 c.m. square, 6 c.m. deep. Window 14·5 c.m. square, yellow leno covered.		1 *o*	1		9	Also one dead, but clearly a (3). Four (3) and the (1 β) on yellow leno window. Six (3)s on roof.
38. Yellow-lined box placed on long side: 14 c.m. by 18·5 c.m. in section, 8·5 c.m. deep. Window 10·5 c.m. by 15 c.m. as above.				9	3	Also two dead, probably a (2) and a (1 β) or (1 γ). All pupæ on roof; mostly in small groups.
39. Yellow-lined box placed on short side: 21 c.m. by 12 c.m. in section, 9 c.m. deep. Window 8 c.m. by 15·5 c.m. as above.			1 *g*	4	3	Also five dead, two emerged and one emerging, but all certainly (2)s or (3)s. Ten on roof, six on left side (three (2)s and three dead).
40. White box (31·5 cm. by 16 c.m. by 6 c.m. deep) with yellow leno window (11 c.m. by 23.5 c.m.), probably placed upwards.			2 *g*, *y*	2		Also three emerging; they were either (2) or (3), or in one case possibly a (1 γ). All attached to edge of leno, where pasted to box.
41. Green cabbage-leaves.				1	6	All seven on separate leaves, except that there was another dead one, certainly a (3), on the same leaf as one of them. Also one pupa dead, but certainly a (3), and two emerged, both (2) or (3). Also a pair on one leaf, one dead and one emerged, both certainly (3s).
42. Dark purple-lined box with white roof, in very dim light: (12 c.m. by 19·5 c.m. by 7 c.m. deep).			6 *g*	9	1	Also six dead probably three (2)s, one (2) or (1 γ), one (2) or (3), one (1 β) or (1 γ). Also one emerged; probably a (2). All tabulated pupæ on white roof, except two (2)s, loose on floor. All pupæ very much undersized.
43. White opal gas globe (usual size).				1	1	Pupæ isolated in upper part of globe.

Experiments.		(1) Dark. (α)	Inter-mediate. (β)	Light. (γ)	Whitish-Yellow. (2)	Green. (3)	Remarks.
Four-compartmented white-lined box, placed on side, with clear glass front. Dimensions same as 17 to 20.	44. Compartment A.			2 *g*			Pupæ on roof, isolated.
	45. Compartment B.		1 *g*			1	Also two dead or emerging, probably (1 β), or perhaps (1 γ) in one case. All pupæ on roof, three crowded.
	46. Compartment C.		1 *g*	1 *y*			One on roof, one on floor (case having doubtless been turned over).
	47. Compartment D.		2 *g*		1		Two on roof isolated, one on back.
48. Rectangular glass case with three sides lined with white paper, and white opal glass roof (20·4 c.m. square, 30·6 c.m. high).			2 *g*	1 *g*			Two pupæ isolated on roof. One (1 β) on black binding of angle between window and side, but close to white paper.

The effects of a dull surface of perforated *zinc* (9—11) and of *brown paper* (12) were, as might be expected, practically the same as those of black.

Salmon paper (13) acted like *orange* (14—29), and produced the lightest and greenest form of pupa. The results of so many experiments with *orange* are very striking, especially as a very deep reddish-orange surface paper was employed.

Yellow (30—40) also produced striking results in the same direction, but not equal in the proportion of the greenest pupæ, to those of *orange*.

Green cabbage-leaves (41) acted like *orange*.

Experiment 42 was very mixed, the pupæ being, almost all of them, fixed to a *white* surface in a *dark purple* box in a very dim light. They were strongly on the light side of intermediate.

White (43—48) has been already described as producing pupæ on the dark side of intermediate (see p. 409). There are, however, some few marked exceptions in both Mr. Merrifield's and my experiments, in which the lightest and greenest pupæ were obtained.

Thus Mr. Merrifield's and my experiments in 1898

afford most useful confirmation in the case of a species which has not been hitherto sufficiently tested, besides bringing evidence of its behaviour under conditions as yet hardly tried at all. In the next section is recorded an experiment upon the same species, which, more than all others, needed repetition because of the important conclusions which follow from it.

4. Experiments with Conflicting Colours upon the Winter Pupæ of *Pieris brassicæ*. (E. B. P.)

I had long been anxious to repeat some of these experiments upon the species of *Pierinæ* because of their extreme suitability for such an investigation and because of the important conclusions which follow from the results.

It had been originally supposed by Mrs. M. E. Barber (Trans. Ent. Soc. 1874, p. 519) that particoloured pupæ are produced by a particoloured surface—a conclusion which naturally followed from the views held by many at that time as to a direct "sun-picture or photograph" on the fresh, moist skin of the pupa. A single pupa of *Papilio nireus* had seemed to support this conclusion.

In 1886 I made a large number of conflicting colour experiments on *Vanessa urticæ* (Phil. Trans. 1887, *l. c.* pp. 368—392). The contrasted colours were, however, only applied during Stage III when the larvæ are suspended preparatory to pupation and are less sensitive than at an earlier period. Nevertheless the results were sufficient to make it highly improbable that any parti-coloration of the pupal surface could occur as the result of such a mixed stimulus, and led to the conclusion that the effects were due to the intermediation of the nervous system in the central parts of which the opposing influences from different regions of the body met and produced more or less of an equilibrium, resulting in the dispatch to all parts of the body surface of stimuli producing intermediate effects. These conclusions were so far-reaching and important that it was necessary if possible to repeat the experiments with other species in which the conditions were more favourable. Although such experiments were not made in 1886 upon the *Pierinæ*, it was clearly seen, when the paper came to be written, that they would be peculiarly suitable for the purpose, because of the great length of the whole sensitive period and the fact that its two stages are both passed under conditions which are eminently favourable for such

an investigation. A few such experiments upon *P. rapæ* were attempted by G. C. Griffiths in 1887 (Trans. Ent. Soc. 1888, pp. 265, 266), and the results upon the whole supported those obtained in the case of *V. urticæ.* But the experiments were not very convincing because the colours employed were not those which produce the most marked and opposite effects.

In 1888 I made some experiments of the kind upon *P. rapæ* and *P. brassicæ* (Trans. Ent. Soc. 1892, pp. 445, 446 and 484), using a box lined with black and orange squares, but owing to the excessive mortality from the attacks of ichneumons only 6 of the latter and 2 of the former could be tabulated. The results however entirely confirmed the experiments made in 1886 upon *V. urticæ*, intermediate and not parti-coloured pupæ being always obtained. In 1892 I made a large number of experiments upon *Vanessa io* (*l. c.* pp. 420—426), and again upon *V. urticæ* (*l. c.* pp. 391—397). Furthermore a method had by then been arrived at which enabled the larvæ of the *Vanessidæ* to be subjected to conflicting colours during the whole of the sensitive period; and another method whereby the dorsal and ventral surfaces could be subjected to opposing stimuli (in the case of *V. io*, *l. c.*). In all previous experiments the anterior and posterior parts of the body had been thus treated. All such modifications and additions yielded confirmatory results.

I was nevertheless very anxious to repeat the experiments upon the *Picrinæ* and therefore took advantage of the abundance of *P. brassicæ* last year (1898). Here, again, however, owing to the *Ichneumonidæ*, my results were not at all what I had anticipated; but taking them in combination with those which have been already published they leave little or no room for doubt.

Two conflicting colour-boxes were made for me by Mr. W. Holland and Mr. A. H. Hamm. The first box had an internal section of 54·5 c.m. by 14·2 c.m., and a depth of 7·4 c.m. (from back to front in the position made use of). It was used resting on one long side with a clear glass front. The roof (the side uppermost in the position in which a receptacle is used is here always called the "roof") was divided into 9 bays of about equal size by means of 8 hanging partitions (each 7·4 c.m. deep and thus extending from the back to the clear glass front, and hanging down for a distance of 3·5 c.m.); while the back

was similarly divided into 10 bays by 9 partitions which alternated with those of the roof. These were 9·0 c.m. high and their lower borders 2·0 c.m. from the floor, while they projected 3·5 c.m. from the back towards the glass front. The object of this division of the internal surface was to separate the larvæ as much as possible, and thus minimise their influence upon each other during the sensitive period. The whole internal surface, except the floor, of the box, and both surfaces of all the partitions were lined with a chess-board pattern of orange and black, each 1·4 c.m. square, and thus as nearly as possible half the length of an average mature larvæ of *P. brassicæ* when resting in Stage II preparatory to pupation. The pattern was made by ruling the outlines of the squares in pencil upon a sheet of deep orange surface paper and then carefully pasting black tissue-paper squares over alternate orange squares.

It is much to be regretted that an experiment conducted with so much care should have produced such limited results as regards the numbers of pupæ.

The first box only contained 3 pupæ which could be tabulated with certainty on May 6th when the examination was made. All were fixed in the left-hand bay of the roof, near to the glass window.

One pupa was fixed diagonally across a black square with the end of its tail lying on another one, and the head, directed towards the light, overhanging an orange square. It was dead but had clearly been a (2) or a (3).

The second was fixed parallel with the glass, the posterior $\frac{3}{5}$ of its body on the anterior part of a black square, but a little overhanging an orange square in front, and the anterior $\frac{2}{5}$ similarly on orange and overhanging black as well as orange in front (viz. towards light). It was a greenish (1 β).

The third pupa was also parallel with the glass, although the tail curved towards it. The posterior $\frac{2}{3}$ of its body was on the posterior (viz. away from glass) border of (so that the right side overhung) a black square, the anterior $\frac{1}{3}$ similarly on and similarly overhung orange. The left side (away from glass) overhung the opposite colours in each case except the posterior $\frac{1}{6}$ which curved towards light, viz. towards the middle of the black square, so as to overhang black. The pupa was a greenish (1 γ).

There were also two other dead pupæ which could be

placed with tolerable accuracy, by an examination of the persistent cuticular pigment.

One of these pupæ was at the back of the roof in the same bay as those described above. It was chiefly upon the black, extending obliquely across parts of two black squares which were in contact at the junction of its anterior and middle thirds; at this point therefore and on each side it, the sides of the body overhung orange. There was very little pigment and it had been certainly not darker than a (1 γ), and probably either a (2) or (3).

The second pupa was on the roof of the bay at the opposite end of the box, close to the hanging partition. Its anterior half was on black, its posterior on orange, crossing almost at the middle of the adjacent sides of the squares; its head towards the light. It had probably been a (1 β).

Although these five pupæ had been subjected to the most strongly contrasted influences in various regions of their bodies, there was not, in a single instance, the faintest trace of parti-coloration. The opposing influences gave rise to a general effect which was almost exactly intermediate between the effects which they would have respectively produced if they had acted alone. It is to be noted that if there is any deviation from the intermediate position it is in the direction of the effects produced by orange. The larvæ seem upon the whole to have rested in contact with black in preference to orange, and thus overhung the latter colour rather more than the former. But many more experiments would be required in order to estimate exactly the relative strengths of these two opposing influences; and it is noteworthy that the results of my experiments upon this species in 1888 led to different conclusions upon this point.

The second box was 43·6 c.m. × 15·4 c.m. in internal section and had a depth of 10· c.m. It was similarly arranged with 6 hanging partitions, and 7 projecting from the back each 8·5 c.m. long but in other respects similar.

The second box was examined on May 7th. In this case six had pupated on the glass. Of two isolated pupæ, fixed in a vertical position with head uppermost, one had emerged and one was dead or emerging; both were probably (1 γ). Two more, similarly placed, were dead and could not be classified. Of two near together, but

otherwise similarly fixed, one was a greenish (1 γ) and one, emerging, was probably a (1 γ) or (2).

Two pupæ were fixed to the parti-coloured surface of the roof. Of these one diagonally crossed two black squares in a manner very similar to that of the first described of the two dead pupæ in the first box, which could not be classified with certainty. The direction of the body was oblique with the head away from the light. It had emerged, but had clearly been a (2) or (3). The second was fixed in another bay, near to and parallel with the glass. The posterior $\frac{2}{3}$ of the body crossed a black square, the anterior $\frac{1}{3}$ was on the next orange one. It had emerged but had evidently been a (1 β) with quite dark pigmentation. There was *no trace* of less pigmentation in the anterior third of its body.

These results entirely confirm those obtained in the first box.

Although further experiments of this kind are to be desired, especially upon so sensitive a species as *P. napi*, it may be regarded as certain that the conclusions derived from the earlier experiments with conflicting colours are sound, and that not parti-coloured pupæ but uniform intermediate ones are obtained in this way.

F.—NOTES ON THE STRUGGLE FOR EXISTENCE IN THE LARVÆ OF *Pieris brassicæ*. (E. B. P.)

I have previously noted the numbers of this species which perish from the attacks of parasites in a year in which the larvæ are specially abundant. It seemed of interest to obtain further records, and I accordingly asked Mr. Holland and Mr. Hamm to keep notes of the number of larvæ attacked by ichneumons and the numbers dying apparently from other causes, which they removed from the cases containing the mixed larvæ from St. Helens and Oxford (see p. 409). The results are recorded in the table on the following page.

In the breeding-cases from which these larvæ were removed only 121 pupæ were taken, including the dead ones; so that the extinction is on a vast scale. Even if it be conceded that the larvæ dying without the appearance of parasites, and the dead pupæ, were entirely due to the conditions of experiment (such as the possible introduction and spread of some form of bacterial disease), the

extinction due to the attacks of a single species of parasite is still immense, only about $\frac{2}{7}$ of the whole surviving it.

		Number of Larvæ attacked by *Ichneumonidæ*.	Number of deaths apparently due to other causes.
1898.	Sept. 22	23	—
	,, 23	25	—
	,, 24	70	—
	,, 26	227	20
	,, 27	64	18
	,, 28	96	29
	,, 29	47	3
	,, 30	54	71
	Oct. 1	37	2
	,, 2	107	—
	,, 3	2	49
	,, 5	145	32
	,, 6	42	7
	,, 8	35	17
	,, 11	11	5
1899		at least 31	at least 20
		Total 1016	Total 273

G.—EXPERIMENTS UPON THE PUPÆ OF *Pieris rapæ*.

1. Experiments upon the Winter Pupæ of *Pieris rapæ*. (F. M.)

The next experiments tried were on this species and are detailed in the following section. I was late for this species and did not experiment with more than 50 or 60 larvæ, from which I obtained the single row of about 40 pupæ which are now shown in the Exhibition Case. Here I call attention to the contrast between those in the black surroundings on the one hand and those in the green paper, yellow, or orange surroundings on the other, the green in this species seeming more effective than it proved with the other species and the yellow less so.

2. Results of the above Experiments. (E. B. P.)

The colour variations of the pupæ of *P. rapæ* have been already described and figured (Phil. Trans. 1887, *l. c.* pp. 410, 411, Plate 26, figs. 31—41), and it is here only necessary to state that the standard classification begins with the darkest pupæ (1), ranging through the less dark (2) and still lighter (3) to the pale (4) and the green (5).

Mr. Merrifield's pupæ were compared on March 20, 1899: the results are given below without much detail,

inasmuch as the species is already known to be susceptible. In addition to those tabulated below, Mr. A. H. Hamm found two very dark pupæ, evidently (1), on a tarred fence near Oxford, on April 2, 1899.

All the (5)s were bright green and very pronounced

Experiments.	Degrees of Pupal Colour.					Remarks.
	Darkest. (1)	Less dark. (2)	Still lighter. (3)	Pale. (4)	Green. (5)	
1. Black.	2					Also 2 dead.
2. Black, on glass.			2			Pinkish ground-colour.
3. Dirty white paint.			1			Very dull, dark pupa. Removed from *P. napi*.
4. Darkness.			4	1		(3) Pinkish: (4) greenish.
5. Green.				1	1	Also 1 dead: (4) greenish.
6. Green, through glass.				1		Also 1 dead or emerging. (4) light pinkish.
7. Green screen.				1		Also 1 dead. Pupa greenish.
8. White, on glass.				2		1 greenish, 1 pinkish.
9. Yellow.				1	1	(4) greenish.
10. Yellow in shade.				1	1	(4) greenish.
11. Yellow on glass.					2	
12. Orange.		1		1	2	Also 1 dead: (4) pinkish.
13. Orange screen.					1	Also 1 dead (removed from *P. napi*).
14. Clear glass.	1	3	1			Also 1 dead.

representations of this degree. A few other conditions were tried, but the single pupæ subjected to them had died and the colour had changed so greatly that they could not be tabulated.

The numbers of the pupæ are not large and the results quite confirmatory of previous experiments. (Phil. Trans.

1887, *l. c.*, and Trans. Ent. Soc. Lond. 1892, *l. c.*: see also G. C. Griffith's experiments on this species in Trans. Ent. Soc. Lond. 1888, p. 247.)

It is interesting to observe the relation between the effects of darkness (4) and those of clear glass (14). The latter produced even darker pupæ relatively to the former than in the case of *P. brassicæ*.

The table does not support Mr. Merrifield's conclusion that the yellow (9, 10, 11) was less effective than in the case of *P. brassicæ*. The six pupæ were of the two lightest degrees, four of them green and the other two greenish.

The effect of the green and orange screens (7, 13) is confirmatory of previous results with other species (*P. brassicæ* and *V. io*).

It is not necessary to comment further upon the other results, all of which will be clear upon an inspection of the table on p. 423.

H.—EXPERIMENTS UPON THE PUPÆ OF *Vanessidæ*.

1. Experiments upon the Pupæ of *Vanessa urticæ* and *Pyrameis cardui*. (C. B. S. and E. B. P.)

In the course of our investigations in 1898 into the struggle for existence during the pupal period of *Vanessa urticæ* it was necessary to produce a very large number of pupæ with colours as widely contrasted as possible. In order to achieve this we made use of black surroundings on the one hand and gilt (Dutch "gold"), yellow, orange, and white on the other. There was abundant evidence in the 700 pupæ which we obtained of the previously recorded influence of these surroundings, and also, to our frequent annoyance, of the effect of the dark surfaces of the larvæ upon one another. In fact so powerful was this influence and so gregarious were the larvæ under the conditions of our experiments that intermediate pupæ were generally produced when the lightest forms were desired. The conditions of the investigation rendered it impossible to isolate so many larvæ in separate cases.

Many of the larvæ pupated on the leaves and stems of the food-plant (nettle), and when isolated brilliant golden pupæ were almost invariably produced.

A few larvæ of *P. cardui* were also found and subjected to black and white surroundings: the pupæ being dark in the one case, and light, and often brilliantly metallic, in the other.

2. Experiments upon the Pupæ of *Vanessa io.* (Mabel E. Notley, Florence A. Wright, and E. B. P.)

The experiments of last year upon the struggle for existence during the pupal period are now being repeated in the case of *Vanessa io.* In this case all the pupæ were obtained at the outset of the investigation, and the results as regards their colour susceptibility can now be given.

We are greatly indebted to Mr. W. Farren of Cambridge, and to Mr. H. W. Head of Scarborough, who sent us numerous companies of larvæ in excellent condition. Kind help was also received from Mr. W. H. Harwood of Colchester, and from Mr. A. E. Holdway of Newton Abbot.

The larvæ thus obtained were placed in a large number of "light" and "dark" receptacles, the former being lined with orange, yellow, or white paper (white opal glass was used in the case of a few larvæ), the latter with black paper (a few were attached to the dull surface of perforated zinc). All were placed in a strong light and only shielded from the direct rays of the sun. A few were subjected to conflicting colours in one of the boxes described on pp. 418, 419.

The results obtained are tabulated below (see p. 426), the degrees of pupal colour being those described in Trans. Ent. Soc. Lond. 1892, p. 398; the (1)s and (2)s being the darkest forms with the underlying green completely or very nearly concealed by pigment which is blacker in (1), lighter in (2); the (4)s and (5)s being distinct green forms very bright and glittering in (5), duller and with more dark pigment in (4); the (3)s intermediate.

The pupæ which were attached to the nettle-leaves, leaf-stalks or stems are indicated by the letter *n*, and those found loose on the floor by the letter *f*. These facts were not however recorded at the beginning of the experiments so that more pupæ were in reality found in these positions in the companies received at first. The facts are important inasmuch as the pupæ on the floor were adversely influenced in the experiments with light surroundings, the pupæ on the nettles in the experiments with dark.

The companies are tabulated separately below, but it was not thought necessary to describe each separate receptacle, as this work is confirmatory. The numerous receptacles in which the larvæ of each company were placed are grouped together as "light surroundings," and "dark surroundings."

Companies of Larvæ.	Conditions of Experiments.	Degrees of Pupal Colour. (1)	(2)	(3)	(4)	(5)	Totals.
Company of 64 larvæ (3 died), received July 11, from W. Farren of Cambridge.	Light surroundings.			2	11	22 (3 *n.*)	35 (3 *n.*)
	Dark surroundings.	4	9 (1 *n.*)	11 (3 *n.*)	1	1 (1 *f.*)	26 (4 *n.*) (1 *f.*)
Company of 172 larvæ (26 died), received July 11, from W. Farren of Cambridge.	Light surroundings.	1	2 (1 *f.*)	7 (3 *f.*)	26 (8 *n.*) (3 *f.*)	90 (21 *n.*) (3 *f.*)	126 (29 *n.*) (10 *f.*)
	Dark surroundings.	9 (1 *n.*) (2 *f.*)	4 (1 *n.*)	3 (1 *n.*)	1 (1 *n.*)	3 (1 *n.*)	20 (5 *n.*) (2 *f.*)
Company of 163 larvæ (16 died), received July 13, from W. Farren of Cambridge.	Light surroundings.		4 (1 *f.*)	2	2	72 (33 *n.*)	80 (33 *n.*) (1 *f.*)
	Dark surroundings.	10	44	9	1	3	67
Company of 87 larvæ (16 died), received July 14, from W. H. Harwood of Colchester.	Light surroundings.	2	4	3 (1 *n.*)	3	31 (13 *n.*)	43 (14 *n.*)
	Dark surroundings.	8 (2 *n.*)	10 (5 *n.*)	4 (4 *n.*)	2 (2 *n.*)	4 (4 *n.*)	28 (17 *n.*)
Company of 57 larvæ (16 died), received July 14, from W. H. Harwood of Colchester.	Light surroundings.		1	2	4 (1 *f.*)	29 (9 *n.*) (1 *f.*)	36 (9 *n.*) (2 *f.*)
	Dark surroundings.	3	1	1			5
Company of 148 larvæ (8 died), received July 14, from H. W. Head of Scarborough.	Light surroundings.	4	1	13 (2 *n.*)	9 (1 *n.*)	83 (16 *n.*) (2 *f.*)	110 (19 *n.*) (2 *f.*)
	Dark surroundings.	2	20	4 (1 *f.*)	1	3 (2 *n.*) (1 *f.*)	30 (2 *n.*) (2 *f.*)
Company of 18 larvæ (11 died), received July 15, from Torquay from A. E. Holdway.	Light surroundings.					7 (3 *n.*)	7 (3 *n.*)
Company of 112 larvæ (21 died), received July 15, from W. Farren of Cambridge.	Light surroundings.			4	3 (1 *n.*)	29 (11 *n.*)	36 (12 *n.*)
	Dark surroundings.	15 (1 *f.*)	28	5 (1 *f.*)	5	2 (2 *n.*)	55 (2 *n.*) (2 *f.*)

Companies of Larvæ.	Conditions of Experiments.	Degrees of Pupal Colour. (1)	(2)	(3)	(4)	(5)	Totals.
Company of 185 larvæ, received July 15, from H. W. Head of Scarborough.	Light surroundings.		13	11	15 (1 *n.*)	84 (10 *n.*) (2 *f.*)	123 (11 *n.*) (2 *f.*)
	Dark surroundings.	10	50 (2 *n.*) (1 *f.*)		1 (1 *n.*)	1	62 (3 *n*). (1 *f.*)
Company of 46 larvæ (2 died), received July 19, from H. W. Head of Scarborough.	Dark surroundings.	11 (1 *n.*)	19 (3 *n.*)	9 (2 *n.*)	3 (2 *n.*)	2	44 (8 *n.*)
Company of 139 larvæ (37 died) received July 19, from H. W. Head of Scarborough.	Light surroundings.	1	7 (7 *f.*)	8 (2 *n.*) (3 *f.*)	5 (2 *n.*)	17 (1 *n.*) (1 *f.*)	38 (5 *n.*) (11 *f.*)
	Dark surroundings.	8 (1 *n.*) (1 *f.*)	32 (5 *n.*) (14 *f.*)	19 (1 *n.*) (13 *f.*)	4 (4 *f.*)	1 (1 *n.*)	64 (8 *n.*) (32 *f.*)
Company of 25 larvæ, received July 21, from H. W. Head of Scarborough.	Light surroundings.			1	1	15 (4 *n.*) (1 *f.*)	17 (4 *n.*) (1 *f.*)
	Conflicting surroundings.		1	2	5		8
Company of 70 larvæ (8 died), received July 21, from H. W. Head of Scarborough.	Dark surroundings.	20	31 (4 *n.*)	6 (4 *n.*)	3 (1 *n.*)	2 (2 *n.*)	62 (11 *n.*)

	Totals.	Degrees of Pupal Colour. (1)	(2)	(3)	(4)	(5)	Totals.
Companies experimented on in 1899, 13. Total number of larvæ, 1302 (180 died).	Light surroundings.	8	32 (9 *f.*)	53 (5 *n.*) (6 *f.*)	79 (13 *n.*) (4 *f.*)	479 (124 *n.*) (10 *f.*)	651 (142 *n.*) (29 *f.*)
	Dark surroundings.	100 (5 *n.*) (4 *f.*)	248 (21 *n.*) (15 *f.*)	71 (15 *n.*) (15 *f.*)	22 (7 *n.*) (4 *f.*)	22 (12 *n.*) (2 *f.*)	463 (60 *n.*) (40 *f.*)
	Conflicting surroundings.		1	2	5		8

These results prove the extreme sensitiveness of *V.-io*, and they afford valuable and very extensive confirmation of some of the results described in Trans. Ent. Soc. Lond. 1892, pp. 397—432.

I.—EXPERIMENTS AND OBSERVATIONS UPON THE SUSCEPTIBILITY OF CERTAIN LEPIDOPTEROUS LARVÆ AND PUPÆ TO THE COLOURS OF THEIR SURROUNDINGS. (A. H. HAMM and E. B. P.)

1. *Stauropus fagi.* Mr. W. Holland and Mr. A. H. Hamm of the Hope Department, who are extremely skilled and accurate observers, drew my attention last year (1898) to the fact that the larvæ of this species differ in tint according as they are reared upon beech or birch, and that the colours are in each case such as to conceal them.

During the present year Mr. Hamm reared two batches (from different parents) upon the same food-plant, beech, but in other respects under very different conditions as regards environment. One of the batches was reared in a white tissue-paper lined rectangular glass case with a perforated zinc lid, the other in a similar case lined with black tissue-paper. We compared the two, placing both batches on white paper, on July 13, 1899.

There were 24 larvæ in the batch reared in the white case, and of these all but 2 were in the last stage and mostly advanced in it. All but 1 were *much* lighter than larvæ of this species usually met with in nature, and some most markedly lighter. The other batch consisted of 14 larvæ, of which 10 were in the last stage (mostly advanced), 1 in the last but one, and 3 in the last but two. All were very dark, and most of them far darker than those generally met with in nature. It is clear that this species is highly sensitive, and it would be of great interest to repeat the experiments under conditions which have been found in other larvæ to produce the strongest effects. It is remarkable that such considerable results followed from surroundings which were not apparently in contact with the larvæ (for these at any rate when they were examined rested upon the twigs and not upon the walls of the case). I do not think, in any of the previous experiments with larvæ, that equal effects have been produced in this manner; and one is tempted to enquire whether it is possible that the larvæ in earlier and specially sensitive stages, did actually rest upon the black and white walls of the cases.

2. *Notodonta ziczac.* My friend Mr. Arthur Sidgwick showed me, in the summer of last year (1898), a larva of

this species which he had obtained from *Populus alba*, and I was greatly struck by the remarkable lightness of its tint. It was quite unlike any larva of the species I had ever seen. Mr. A. H. Hamm informs me that he has also observed great differences in the depth of colour of this larva according to the food-plant upon which it has been found. It is highly probable therefore that this species is also sensitive, and searching experiments upon it are greatly needed.

This case and the last are of high interest, inasmuch as no larva at all closely allied to these two species has yet been shown to be sensitive to the colours of its environment.

3. *Amphidasis betularia.* Mr. A. H. Hamm tells me that he has again and again observed in nature the wide differences between the colours of this highly sensitive larva upon various food-plants, and that the differences are invariably in the direction of concealment. Mr. Hamm's experience in the field is so wide and his powers of observation so keen that the strongest confirmation is afforded to the observations recorded in my previous paper (Trans. Ent. Soc. Lond. 1892, pp. 359, 360).

4. *Eupithecia pimpinellata.* Mr. Merrifield informs me that Mr. Nicholson (of Lewes) has noticed that this larva appears in two forms—reddish-brown and green—which correspond to the two forms of the seed-heads of *Pimpinella saxifraga* on which it feeds. Mr. Nicholson states that the green larvæ are nearly always found on the green heads and the others on the brown.

The power of colour adjustment is probably present in a very high degree in the larvæ of the genus, and numerous carefully conducted experiments are much to be desired.

5. *Vanessa polychloros.* I may also mention that a pupa of this species which I found (July 1899) upon the dark painted iron railing at the North Entrance Gate of the Oxford University Museum, harmonised very perfectly with the surface from which it was suspended.

6. *Vanessa antiopa.* In August 1897 I found several living pupæ of this species attached to fences, buildings, etc., at the Hunt Club, Scarborough Heights, Toronto. I specially noticed that there was a marked resemblance to the environment. This was all the more noticeable inasmuch as the colours differed very widely, some surfaces being very dark and others very light.

K.—OBSERVATIONS ON THE COLOUR-RELATION BETWEEN A COLEOPTEROUS SPECIES (*Cleonus sulcirostris*) AND ITS SURROUNDINGS. (W. HOLLAND and E. B. P.)

The Rhynchophorous species *Cleonus sulcirostris* is described as possessing very variable markings (Fowler, *British Coleoptera*, London, 1891). Mr. W. Holland has recently found it upon the red sands of Boar's Hill near Oxford, and it is most interesting to observe that all the specimens are reddish-brown in colour, entirely different from the grey forms found by him on the sand-hills at Deal, and from the darker grey ones which he finds on Shotover Hill also near to Oxford and only a few miles from Boar's Hill. There are yellow and red sands on the top of Shotover, but Mr. Holland has as yet only searched for this species in localities where they are not exposed on the surface. There have been no exceptions to the colours of the very large numbers found on both hills. It is reasonable to suppose that these colours, which certainly harmonise with the ground of each locality, are protective; inasmuch as the species possesses in a very high degree the instincts which lead to concealment.

So far as I am aware this is the first time that such local adaptation of colour has been shown to occur in a Coleopterous insect, and the interesting question arises as to whether the species possesses the power of varying its colour during growth according to the stimulus provided by the colours of its surroundings, or whether the results are due to the varying operation of natural selection in different localities leading in each case to the survival of the individuals which are best concealed.

It will be of the highest interest to look for further examples in Coleoptera, as well as to attempt to ascertain the manner in which the colour adaptation is brought about.

L.—APPENDIX.

THE QUALITY OF LIGHT FROM THE COLOURED AND OTHER BACKGROUNDS EMPLOYED IN THE EXPERIMENTS RECORDED IN THE PRESENT MEMOIR. (SIR JOHN CONROY and E. B. P.)

My kind friend Sir John Conroy, F.R.S., again helped me to make a correct analysis of the light reflected from the backgrounds employed in our experiments. The papers, etc., were examined in the Laboratory of Balliol College, Oxford, on July 24th, 1899. The beam from an electric arc was passed through a bisulphide of carbon prism, and the spectrum thrown on a white paper screen in a darkened room. The coloured papers, etc., were held so as partly to cover the spectrum, and sometimes two were held in the spectrum side by side for purposes of comparison. The method was thus the same as that made use of on the previous occasion (Trans. Ent Soc. 1892, *l. c.* pp. 459 *et seqq.*), except that the lime-light illumination was then employed, and our spectrum was therefore weaker at the blue end than with the electric arc. The results obtained are recorded below.

I. *Coloured backgrounds, etc., employed by F. Merrifield:—*

Black net and *black tissue-paper* (used as a plane surface and also rolled round sticks). The reflected light from both gave a feeble continuous spectrum. The transmitted light was the same but still feebler.

Dark sticks also gave a faint continuous spectrum: *cork carpet* was similar except that the reflected red was prominent.

Orange tissue-paper (used as a plane surface and also rolled round sticks). Some absorption of green and more of blue and violet; absorption more marked in the sticks where there was more than one thickness of the paper. No appreciable difference between the reflected and transmitted spectrum of the paper. The spectrum was far more like that of a yellow paper than of the deep orange used in my experiments, which removed everything except the red, orange, and yellow.

Orange leno gave a very similar spectrum, the blue and violet being almost cut off, and the green a little darkened.

The absorption was more marked in the transmitted light.

Yellow tissue-paper (also rolled round sticks). Violet cut off and blue much diminished; hardly any blue in the transmitted light, and in the thicknesses of paper rolled round sticks.

Golden yellow oat-straw gave a very similar spectrum, the blue and violet being absorbed and the rest unaffected.

Unfaded bright yellowish-green tissue-paper (also rolled round sticks). The red shortened and dimmed; the blue and violet much absorbed. Transmitted light similar, as also the reflected light from the paper round sticks.

Bright yellowish-green art muslin. A similar spectrum. Not much difference between transmitted and reflected light, except that two thicknesses produced far greater effects in the former.

Dull green reeds. Whole spectrum somewhat weakened, the blue most and then the red.

Yellow metallic surface of brass (*Dutch gold*), also rolled round sticks. Appears to give a strong continuous spectrum, but the yellow colour is due to absorption of the blue end.

Dead reeds. The lightest of them gave a typical yellow spectrum with absorption of the blue end only; in the others there was diminution of all other regions, although the blue end was still most reduced.

Turned cylindrical wooden sticks (probably deal). A very similar spectrum; the blue end was still more absorbed than any other part, although less so than in the dead reeds.

Dirty white paint gave a very similar spectrum with some absorption throughout, most in the blue, least in the green.

White paper rolled round sticks, white calico, shaved white sticks all gave a strong continuous spectrum with no selective absorption.

Yellow glass (used as screen). Blue and violet cut off, the rest unabsorbed.

Deep green glass (used as screen). The green almost unabsorbed. The whole of the blue end, and nearly all the red and orange absorbed.

II. *Coloured backgrounds employed by E. B. Poulton* and those who worked with him.

The *Black papers*, both "surface papers" and tissue-papers, gave the same results as Mr. Merrifield's, and those previously recorded (E. B. Poulton in Trans. Ent. Soc. Lond. 1892, pp. 461—464), and the same was true of the *yellow* papers (surface and tissue) and *yellow leno*, all of which were typical; the *white paper*, and the *white opal glass*. The *deep orange* paper was similar to that I have previously used, and very different to Mr. Merrifield's. The following backgrounds had not been examined before:—

A dull surface of metallic zinc (perforated) gave a dim continuous spectrum (general, but no selective absorption).

Salmon pink surface paper. A very faint absorption of the blue was all that could be seen. The blue also looked redder, an effect which may have been due to the stray white light reddened by selective absorption in the paper.

Violet paper. Much of the blue end, and considerable red were reflected. There was an absorption band between the green and the blue, and the yellow, orange, and green were much absorbed.

Extracted from the PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF LONDON *of December 7th,* 1898.

Dr. DIXEY exhibited a series of Pierid butterflies from the Neotropical region to show the existence among them of seasonal forms. The species shown were *Parura rurina*, Feld., ♂; *P. neocypris*, Hübn., ♂; *Phœbis argante*, Fabr., ♂, ♀; *P. agarithe*, Boisd., ♂; *Callidryas sennæ*, Linn., ♂, ♀; *C. philea*, Linn., ♂. In each case three specimens were shown, exemplifying the "wet season," "dry season," and "intermediate" forms of the species. These had been selected from the Hope Collection by permission of Professor Poulton.

With reference to the exhibit, DR. DIXEY remarked that although direct evidence as to the seasonal changes in these Neotropical species was at present scanty, the indirect evidence was strong; inasmuch as the range of variation here shown was analogous with that existing in certain African and Oriental species, whose seasonal relations had been put on a firm basis by the work of Watson, Barker, Marshall, and others. In every one of the present instances the "wet season" form tended to be more deeply coloured, and to have its markings on the underside more fully developed; while the "dry season" form was usually smaller, had its forewings more sharply pointed, and was nearly or entirely devoid of markings on the underside. He stated further that where evidence of the date of capture existed, it accorded very fairly with the supposition that these variations bore relation to seasonal conditions, though of course more data of this kind were much needed. He had selected the specimens of each species so far as possible from the same locality, endeavouring thus to meet the possible objection that these varieties, several of which had been described as distinct species, might have a local rather than a seasonal significance. He added that by an "intermediate" form he meant simply one that came somewhere between the other two—not necessarily half-way. He was accustomed to use the term in a general sense as equivalent to the German "Zwischenform," not as conveying the idea of an arithmetical mean (Mittelform).

The PRESIDENT observed that the exhibit was of special interest, as affording the first recorded evidence of the existence of seasonal dimorphism in Neotropical butterflies.

RECENT EXPERIMENTS IN HYBRIDISATION.

IT has long been recognised that the facts of hybridisation have an important bearing on many subjects of biological interest. The question of the infertility of crosses was very carefully investigated by Darwin, and since his time has been more than once discussed afresh; while the structural and other characters presented by hybrid offspring are of undoubted weight in reference to the problem of heredity.

For some years past Dr. M. Standfuss, of Zürich, has been experimenting on a large scale in the production of insect hybrids. The results of these experiments, some of which confirm previous views, while others appear to suggest conclusions not hitherto reached, have now been collected by their author in his *Handbuch der paläarktischen Gross-Schmetterlinge,* published at Jena in 1896. Many of the data thus made available derive especial value from the fact that they are expressed numerically, and the whole series forms a noteworthy contribution to our knowledge of the subject. It is proposed to give here a short account of these experiments, with their results, for the benefit of those readers to whom the original records may be difficult of access.[1]

The author prefaces his account with a list of fertile and infertile pairings between different species of macrolepidoptera that have been observed by himself and others, both under natural conditions and in captivity. Details are first given of twenty-four cases of pairing between *Bombyx neustria* L. ♂ and *B franconica* Esp. ♀. The results showed every transition between complete absence of issue and the deposition of eggs normal in numbers and fertility. Failure was in some instances plainly due to inadaptability of the genital apparatus. On this series of pairings Stand-

[1] Several of Dr. Standfuss's specimens have lately been exhibited in London, at the rooms of the Royal Society, Burlington House and at the Natural History Museum, South Kensington.

fuss remarks that the absence of uniformity in the results shows that several trials should be made before any given cross is pronounced infertile.

Five crosses are mentioned from which only male offspring are known to have resulted; these are *Deilephila porcellus* L. ♂ and *D. elpenor* L. ♀; *Smerinthus austauti* Stgr. ♂ and *S. atlanticus* L. ♀; *Fumea nitidella* Hof. ♂ and *F. affinis* Rutt. ♀, with the reciprocal cross *F. affinis* ♂ and *F. nitidella* ♀; *Bombyx neustria* L. ♂ and *B. franconica* Esp. ♀.

In the following five cases only female offspring have been observed, and these contained no eggs capable of development: *Bombyx neustria* L. ♂ and *B. castrensis* var. *veneta* Stdfs. ♀; *B. franconica* Esp. ♂ and *B. castrensis* var. *veneta* ♀; *B. quercus* L. ♂ and *B. trifolii* Esp. ♀; *Saturnia pyri* Schiff ♂ and *S. pavonia* L. ♀; *Drepana curvatula* Bkh. ♂ and *D. falcataria* L. ♀.

In the following seven the males predominate and the females are again sterile: *Deilephila euphorbiæ* L. ♂ and *D. vespertilio* Esp. ♀; *D. hippophaes* Esp. ♂ and *D. vespertilio* Esp. ♀; *Smerinthus ocellatus* L. ♂ and *S. populi* L. ♀; *Saturnia spini* Schiff ♂ and *S. pyri* Schiff ♀; *S. spini* Schiff ♂ and *S. pavonia* L. ♀; *Harpyia vinula* L. ♂ and *H. erminea* Esp. ♀; *Notodonta dromedaria* L. ♂ and *N. torva* Hb. ♀.

The author points out that no fertile female offspring having been observed in any of the above seventeen crosses, none of these hybrids, so far as our present knowledge goes, could continue their race. It is unfortunate that the actual numbers of the broods in question are not given; in some instances, as in that of *B. neustria* ♂ and *B. franconica* ♀ they are presumably large.

In three more crossings the offspring consisted of both sexes in normal proportions; the females, however, contained at best but few eggs, and these abnormal in structure. The crossings were of *Smerinthus populi* L. ♂ and S. *ocellatus* L. ♀; *Saturnia pavonia* L. ♂ and *S. pyri* Schiff ♀; *S. pavonia* L. ♂ and *S. spini* Schiff ♀.

Finally, in two more the sex-distribution appears again

to be as usual, and the females contain ova normal in appearance. Their fertility, however, has not been proved, and Standfuss thinks he has reason to doubt it. These are *Zygæna trifolii* Esp. ♂ and *Z. filipendulæ* L. ♀; *Biston hirtarius* Cl. ♂ and *B. pomonarius* Hb. ♀.

In no single instance, according to Standfuss, has the female of any true hybrid among lepidoptera been shown experimentally to be fertile. Haeckel's counterstatement with regard to the genera *Saturnia* and *Zygæna* is probably erroneous.[1]

The most complete series of Standfuss's experiments in hybridisation is one carried on for over ten years with three species of *Saturnia*, *viz.*, *S. pavonia* L., *S. spini* Schiff, and *S. pyri* Schiff. The results of these experiments are recorded and compared by their author with great minuteness, and excellent figures are given by him of several of the resulting forms in their immature and final stages. A brief outline of these records, omitting details, will here be attempted.

1. *Saturnia pavonia* ♂ and *S. spini* ♀. In this hybrid, called by Standfuss *S. bornemanni*, the eggs first laid were regularly deposited, and were fertile to the extent of from 60 to 80 per cent. The larvæ in all five stages bore a much closer resemblance to those of *S. spini* than to those of *S. pavonia*, though this became less pronounced after the second stage was passed. The cocoon and pupa were both intermediate in structure, but the perfect insect was nearer to *S. spini* than to *S. pavonia*. This applies to both sexes, but is more easily seen in the male, the males of the two parent species differing (as is usual) more than the females.

2. The reciprocal cross (*S. spini* ♂ and *S. pavonia* ♀; = *S. hybrida* Ochs.) has not been produced in captivity,

[1] Standfuss does not notice the case cited from Quatrefages by Wallace (*Darwinism*, 1889, p. 163), of fertility *inter se* in the hybrids between *Bombyx cynthia* and *B. arrindia*. Fletcher also has obtained fertile hybrids of both sexes between *Zygæna lonicerœ* Esp. and *Z. trifolii* (*Proc. Ent. Soc. Lond.*, 1893, p. ix.). On the other hand, the hybrids of *Z. lonicerœ* and *Z. filipendulæ* proved infertile (*Ibid.*, 1891, p. ix.), and the hybrid progeny of various species of *Platysamia* and *Actias* were found by Miss Morton to be sterile in both sexes (*Ibid.*, 1895, p. xxxiv.).

but is repeatedly found in the wild state, generally as a larva. The question naturally suggests itself, how the parentage of this hybrid is known. Standfuss replies that the larva, though intermediate in character, shows constant differences from that of *S. bornemanni*, and that the conditions in nature for the pairing of *S. spini* ♂ and *S. pavonia* ♀ are favourable, whereas those for the converse cross are difficult or impossible. The males of both species emerge before the females, and in regions where both occur *S. pavonia* is out first. Hence, though the females of *S. pavonia* are out with the males of *S. spini*, the converse does not take place. It must be allowed that it would be well to test this conclusion as to the parentage of *S. hybrida* by experiment. The larva of *S. hybrida* resembles *S. pavonia* somewhat more than does that of *S. bornemanni;* it possesses, however, the greasy polish of *S. spini* to a greater extent than the latter. The cocoon and pupa both show a nearer approach to *S. spini* than do those of *S. bornemanni*, and the same applies to the perfect insect; in fact the resemblance of both sexes to the male parent is remarkably close.

3. *S. pavonia* ♂ and *S. pyri* ♀. This crossing produced hybrids which fell into two classes, a dark form called by Standfuss *S. daubii*, and a paler form to which he gives the name *S. emiliæ*. The latter is by far the commoner. As in former cases, if the laying is much deferred after pairing, the eggs are apt to prove infertile. The larva in its early stages is very like that of *S. pyri;* it becomes more and more like that of *S. pavonia*, and finally bears a close resemblance to the latter species. The cocoon is intermediate; the pupa is nearer to *S. pavonia* than to *S. pyri*. The perfect insect, except for a reduction in the sexual disparity of size, is more like an enlarged *S. pavonia* than a diminished *S. pyri*. In a majority of specimens some of the veins were forked terminally at a greater or less distance from the margin of the wings.

The males of this hybrid paired readily with the females of *S. pavonia;* they were also attracted by the female hybrids, though in a less degree. The latter were, as already

stated, infertile, the oviducts containing no ripened eggs. Pairing also took place, though with much less readiness than in either of the preceding cases, between the hybrid males and some females of *S. pyri.* The number of fertile eggs produced in the latter case was far smaller than in the cross with *S. pavonia.*

4. *S. bornemanni* ♂ and *S. pavonia* ♀ (*S. bornemanni* is the cross-product of *S. pavonia* ♂ and *S. spini* ♀). The larvæ at first closely resembled those of *S. pavonia*, but in subsequent stages the influence of *S. spini* began to assert itself. They presented a very variable appearance on reaching the fourth stage, which period unfortunately they did not survive. Fresh batches, however, have since been raised to maturity, though no record of their history has yet been published.[1]

5. *S. emiliæ* ♂ and *S. pavonia* ♀ (*S. emiliæ* is a cross-product of *S. pavonia* ♂ and *S. pyri* ♀). The larvæ of this hybrid (named *S. standfussi* by Wiskott) are again very variable. Their general appearance is that of a large *S. pavonia.* The cocoon and pupa are also near the same parent species. The perfect insect, like the larva, is variable ; it always, however, shows much resemblance to *S. pavonia*, and the sexes are dissimilar as in that species. The margins of the wings are apt to be scalloped. The oviducts of the only female that emerged contained mature eggs, but only about twenty, or one-tenth of the normal number in *S. pavonia* or *S. pyri.* It is possible that these hybrids may be fertile *inter se.*

6. *S. emiliæ* ♂ and *S. pyri* ♀ (*S. risii* Stdfs.). This pairing was only obtained with great difficulty, and in four cases out of nine the eggs, though laid in normal numbers, did not hatch. In the remaining five broods only one per cent. produced caterpillars. These at first closely resembled *S. pyri*, and in the second stage still showed more likeness to *S. pyri* than to the male parent form. In the third stage the *S. pyri* characters began to be lost, and in the fourth

[1] Specimens of this hybrid have been reared by the present writer from eggs kindly sent him by Dr. Standfuss in 1895. Other individuals raised from the same batch of eggs are in the Hope Collection at Oxford.

those of *S. pyri* and *S. pavonia* were fairly balanced. After changing its last skin the larva resembles a large *S. pavonia*, though its parentage is three parts *S. pyri*. The perfect insects, of which only six were reared, were in many respects remarkable. Unlike *S. pyri* they were sexually dimorphic, the females differing little from those of *S. emiliæ*, while the males showed a nearer approach to *S. pyri*. The females were not dissected, but were probably sterile. Of the six specimens, one was hermaphrodite and three others showed a tendency in that direction. These four were the produce of three separate females out of the five that laid living ova. Standfuss draws attention to the fact that the normal occurrence of hermaphrodites in lepidoptera is given by Speyer as about 1 in 30,000. The latter number he considers rather too low than too high. There was no hermaphroditism in any known member of the families of the progenitors of these hybrids; and its appearance in this proportion must be, he thinks, a consequence of their exceptional origin. On the other hand, he has bred more than 1000 genuine hybrids without one such case occurring,[1] nor was any such tendency shown by a single one of the sixteen specimens of *S. standfussi*—a form whose origin is analogous to that of the present cross-product.

In the well-marked hermaphrodite mentioned above, the distribution of sexual characters is remarkable. The shape of the fore wings is rather female than male, the colouring on the upper side of both is male; on the under side, the right is mostly male and the left female. In both hind wings the upper surface has the costal portion male, the remainder female; the right, which is about one-fifth larger than the left, has the female area more extensive. The under surface of the right or larger hind wing is female, of the left mostly male. The right antenna is male in form; the left partly male and partly female. The external genital organs on the right side are of a malformed male type; on the left side absent.

[1] Barrett (*Lepidoptera of the British Islands*, vol., ii., 1895, pp. 10, 11) gives some details of the cross between *Smerinthus ocellatus* and *S. populi*. These are said to be "often gynandrous".

The want of vigour in this cross is shown by the fact that out of nine pairings, each resulting in an average of 200 eggs, only ten larvæ were produced; and of these only six, as we have seen, attained the perfect condition.

7. *S. pavonia* ♂ and *Actias luna* L. ♀. Nine apparently normal pairings took place, and over 1000 eggs were laid; but none of these hatched.

8. *S. pavonia* ♂ and *A. isabellæ* Graëlls ♀. As a result of this crossing, ninety-eight eggs were laid, seven of which hatched. The caterpillars however did not long survive their first change of skin.

9. *S. bornemanni* ♂ and *S. pyri* ♀. As *S. bornemanni* is the cross-product of *S. pavonia* ♂ and *S. spini* ♀, this hybrid is descended from all three species.[1] Only one pairing was obtained, and 92 per cent. of the eggs hatched. Some of the resulting perfect insects were lately shown in London with the other exhibits of Dr. Standfuss, who promises to publish further details of their history.

Relative phylogenetic age of the three European species of Saturnia. Before stating the general conclusions at which he has arrived as a result of the above series of experiments, the author proceeds to discuss the question of the relative phylogenetic age of the three species *Saturnia spini*, *S. pavonia* and *S. pyri*. Of these he considers *S. spini* to be the oldest form and *S. pyri* the most recent. His main reasons are briefly as follows:—

(1) The larva of *S. spini* maintains its original black colour throughout its life. *S. pavonia* loses this sometimes in the third stage, always in the fourth and fifth. *S. pyri* abandons it almost completely in the third stage and onwards. The succeeding green colour, which is no doubt adaptive, is acquired by *S. pyri* at an earlier stage and more completely than by *S. pavonia*.

(2) In the larva of *S. spini* the tubercles are not very prominent even in the adult, and the knobs at their summit are not distinctively coloured until the last stage. In *S.*

[1] Mr. A. G. Butler informs me that an analogous triple cross has been obtained between a goldfinch and the hybrid issue of the English and Japanese greenfinch.

pavonia the tubercles are conspicuous and the knobs acquire an appearance distinct from the general surface of the body in the third or fourth stage. In *S. pyri* on emergence from the egg the knobs are already coloured and indications exist of the extreme prominence of the tubercles.

(3) The tactile bristles are least developed in *S. spini*, most in *S. pyri.*

(4) The cocoon of *S. spini* is simpler than that of *S. pavonia.* That of *S. pyri* is the best defended of the three.

(5) *S. spini* is almost sexually monomorphic, though the male is somewhat the smaller. The female is very sluggish, and the antennæ of the male are pectinate to a high degree. In *S. pavonia* there is well-marked sexual dimorphism, as regards both size and colouring. The female resembles that of *S. spini* in aspect; it is less sluggish, though not very active. The antennæ of the male are less strongly pectinate. *S. pyri* again is sexually monomorphic; the female is a tolerably good flier, and the antennæ in the male are less strongly pectinate than in many other species of *Saturnia.*

Judging from the perfect insects alone, we must conclude, according to Standfuss, that the less specialised *S. spini* is older than *S. pavonia.* We should, however, find it difficult to determine whether *S. pyri* arose before or after the divergence of these two. The larval and pupal stages enable us to answer the question. The three species form a progressive series in protective adaptation, *S. spini* always taking the lowest and *S. pyri* the highest step in the scale. It must therefore be concluded, on the whole evidence, that *S. spini* is phylogenetically the oldest, and *S. pyri* the youngest of the three forms.

General conclusions with reference to hybridisation between distinct species. As the author elsewhere expresses it, the crossing of two distinct species gives rise to a "Zwischenform" but not to a "Mittelform". The Mittelform may, however, exist as a temporary stage in larval growth. This depends on the following principles, which Standfuss considers to be warranted by the above experiments with species of *Saturnia*:—

1. The freshly-hatched larva closely resembles the female parent.

2. With the process of growth a resemblance to the male parent gradually increases.

3. The final extent of approximation towards the male parent depends on the relative phylogenetic age of the two species; the older being able to transmit its properties, whether of structure or habit, better than the younger.

Thus the crossing of *S. pavonia* ♂ with the phylogenetically younger *S. pyri* ♀ gives rise to a larva in which at first the maternal and afterwards the paternal characters predominate.[1] The resulting perfect insect is by more than two-thirds of its external appearance *S. pavonia*, and by less than one-third *S. pyri*. Its habits and functions correspond with its external aspect. It prefers to fly by day, like *S. pavonia* ♂, and pairs easily with the female of that species, from 43 to 62 per cent. of the eggs being fertile. On the other hand, it does not pair readily with *S. pyri*, and the resulting eggs on an average of nine cases gave only one larva from 180.

Similarly *S. pavonia* ♂, when paired with the phylogenetically older *S. spini* ♀, gives a form of which in the perfect state about two-thirds of the external aspect belong to the type of *S. spini*. The male flies by night. After crossing with *S. pavonia* ♀ the resulting eggs were only fertile to the extent of 16 to 22 per cent.; while the crossing with *S. spini* ♀, though not easily brought about in consequence of their diverse times of appearance, yielded eggs of which from 94 to 98 per cent. were fertile.

Thus the male *S. pavonia* is able to influence the issue of the relatively gigantic *S. pyri* ♀ much more than that of *S. spini* ♀.

Again, the issue of *S. spini* ♂ and *S. pavonia* ♀ is much nearer *S. spini* than is that of *S. pavonia* ♂ and *S. spini* ♀. Hence,

4. In reciprocal pairing the male is able to transmit the characters of the species in a higher degree than the female.

[1] Barrett (*loc. cit.*, p. 11) says, quoting Porritt, that the larvæ of the cross between *Smerinthus ocellatus* and *S. populi*, "though like those of *S. populi* when young, appear to become intermediate, or even to resemble those of *S. ocellatus* when full grown".

The above cases show that the former influence, *viz.*, that of the older-established species, is the more effective of the two. The sexual prepotency of the male *S. pavonia* counts for less than the specific prepotency of the female *S. spini.* The highest effect of course is produced when the two influences concur, as in the hybrid of *S. spini* ♂ and *S. pavonia* ♀.

A further result of the experiments is that while no female hybrid was proved to be fertile, there are undoubted cases of fertility in male hybrids. This has been shown by crossing with the females of both parent species, and in one case with a female of a third species (*S. bornemanni* ♂ and *S. pyri* ♀).

Hence hybridisation is not necessarily a merely transitory phenomenon. There seems to be no reason why a male hybrid should not propagate by "back-crossing" under natural conditions; and since the product of this kind of crossing is not found to show a complete reversion to the type of the female parent, it is possible that the existence of various intermediate forms in such genera as *Melitæa*, *Zygæna* and *Agrotis* may be accounted for in this manner. Cases of simple pairing between distinct species of the two former genera have been observed by the author in nature.

The above conclusions with the facts on which they rest, though much condensed from the original, have been stated as far as possible in Dr. Standfuss's own words. A few brief comments seem called for.

(1) The rule laid down by Standfuss as to the prepotency of the phylogenetically older species is probably another expression of the fact so clearly established by Darwin[1] that hybridisation frequently leads to reversion. It is significant that Standfuss considers the hybrid form *S. emiliæ* as partly reproducing an ancestral stage in the history of *S. pavonia* rather than the form of that species at present existing.

(2) It is well known that when plant hybrids are crossed with one of the parent species, considerable variability may

[1] *Animals and Plants under Domestication*, 1868, vol. ii., p. 254, etc.

occur in the offspring (Focke, quoted by Weismann). The facts above recorded as to the results of back-crossing (see accounts of *S. standfussi*, *S. risii*, etc.), show that the same rule holds good with hybrid *Saturnias*.

(3) Some of the above generalisations, at present resting on only a few instances, can hardly be regarded as more than provisional. It will be interesting to see whether the further results of these experiments, which are being continued by their author, tend to confirm or to modify the conclusions previously reached.

Cross-breeding between local races. Akin to the above experiments are others in which local races of the same species were paired. These gave results in many respects analogous with the foregoing.

1. *Callimorpha dominula* L. ♂ and *do.* var. *persona* Hb. ♀. The crossing of *C. dominula* ♂ with var. *persona* ♀, the latter being a local race found only in Tuscany and Calabria, generally produced issue that, though very variable in the perfect state, bore on the whole a closer resemblance to *C. dominula* than to var. *persona*. In one case, however, a majority of the brood came nearer to the latter, and one individual even went beyond the *persona* type. From 3 to 5 per cent. of the eggs were sterile.

2. *C. dominula* var. *persona* ♂ and *C. dominula* ♀. In this, the reciprocal cross, the resulting perfect insects again varied between the parental types, but, on the whole, came nearer to *C. dominula* than to the variety, though less so than those of the former cross. Of the eggs, from 10 to 15 per cent. were sterile, from which Standfuss concludes that the male of var. *persona* has already diverged from the physiological standard of the species.

The products of each crossing are fertile in both sexes, but Standfuss is unable to say whether they have undergone any diminution in fertility as compared with the parent forms.

3. *Ocnogyna hemigena* Grasl. ♂ and *O. zoraida* Grasl. ♀. These are regarded by the author as local races of the same species, the former inhabiting the Pyrenees and the latter the mountains of Andalusia. The cross-product (called by

Staudinger *O. zoragena*) resembles a large *O. hemigena.* According to Kröning the mongrel issue are fertile *inter se*, but quickly degenerate in size and vitality. This of course may be due to other causes than their mixed origin.

4. *Spilosoma mendica* Cl. ♂ and *do.* var. *rustica* Hb. ♀. The larvæ were nearly always formed within the egg; but in some broods not one, and in others only from 8 to 12 per cent. hatched. In one case, however, as many as 93 per cent. of the eggs gave living larvæ. All the broods suffered severely from disease. The perfect insects, which did not show much variation, diverged only slightly in appearance from var. *rustica.* The males were mostly light-coloured, as in that variety, and the darkest of them were far lighter than any male of *S. mendica.*

5. *S. mendica* var. *rustica* ♂ and *S. mendica* ♀. The reciprocal cross, which failed with Standfuss in consequence of an epidemic among the larvæ, was obtained by Caradja. Pupæ sent by him to Standfuss gave thirty-one perfect insects, seventeen being males and fourteen females. These were more variable than the former cross-product, but on the whole inclined towards var. *rustica.*[1]

It is observable that in this case of reciprocal crossing, the influence of the females appears to be equal to if not greater than that of the males. This shows that the generalisation as to male prepotency founded on the case of the *Saturnias* is not of universal application. It will be remembered also that the issue of one of the pairings between *C. dominula* ♂ and var. *persona* ♀ showed female prepotency, though the general result in the case of this and the reciprocal cross tended in the opposite direction.[2]

Standfuss considers that the present experiments with species and their local races favour his view as to the superior influence of the phylogenetically older form.

Aberrations. Some very remarkable facts are recorded

[1] This corresponds, as has been pointed out by Mr. South, with the result obtained by Mr. Adkin, who effected the same cross in 1889. *Vid. Entomologist*, for August, 1897, p. 206; *Proc. Ent. Soc. Lond.*, 1890, p. xl.

[2] See also p. 199, *infra*, note.

as to the effect of crossing a sport or aberration with its parent form. The result, which is entirely different from that which follows the crossing of distinct species, or even of local races, may be broadly stated as follows: When an aberration is crossed with its parent form the issue is sharply divided, in both sexes, into specimens of the aberration and of the normal form of the species.

Thus in the dark aberration *zatima* Cr. of *Spilosoma lubricipeda* Esp., there are many degrees from the least dark form of the aberration (ab. *intermedia* Bang-Haas) up to the darkest (ab. *deschangei* Depuis); but no transitional forms occur to bridge over the wide gap between *intermedia* and *lubricipeda*, nor can they be produced by crossing these two. "It seems," so Standfuss expresses it, "as if there were antagonistic characters which cannot coexist in the same individual".[1] Instances follow which will be briefly noticed here. For full details, which are of great interest, the reader is referred to the *Handbuch*, pp. 305-321.

1. *Spilosoma lubricipeda* Esp. ♂ and *do.* var. *zatima* Cr. ♀. These, crossed by Burckhardt in 1889, gave *lubricipeda*, *intermedia* and *zatima* (*intermedia* being, as just stated, merely a less dark form of *zatima*). Two of these *intermedia* were paired, giving again *lubricipeda*, *intermedia* and *zatima*. In this third generation several pairings were effected, as follows: *zatima* ♂ and *lubricipeda* ♀; *lubricipeda* ♂ and *zatima* ♀; *intermedia* ♂ and *do.* ♀; *intermedia* ♂ and *zatima* ♀. All these gave *lubricipeda*, *intermedia* and *zatima* in varying proportions, except the cross *lubricipeda* ♂ and *zatima* ♀, from which only *zatima* resulted. A pair of *lubricipeda* from this fourth generation gave a brood of 34 *lubricipeda* and 1 extreme *zatima*.

In all these successive broods, carried on into the fourth year from the date of the original pairing, there were no transitional forms between *lubricipeda* and *intermedia*.[2]

[1] The bearing of this may be noted on the theory of "determinants". See Weismann, *Germ-plasm*, 1893, pp. 293, etc. See also Bateson, *Materials for the Study of Variation*, 1894, esp. Intro., Sect. iii.; and this Review, 1897, pp. 554-569.

[2] The above case of cross-breeding between colour-varieties of the same race, in which there are no intermediates and the colours of the ancestors

2. *Psilura monacha* L. ♂ and *do.* ab. *eremita* O. ♀. In 1893 Standfuss raised a brood from a pair of normal *P. monacha* received from Silesia. This brood contained one female specimen of the dark aberration *eremita*, which was paired with a normal *P. monacha* ♂ from Zürich. The issue consisted of 22 (2 ♂ and 20 ♀) typical *monacha*, 23 (18 ♂ and 5 ♀) typical *eremita*, and 6 forms (5 ♂ and 1 ♀) in which the characters of the two are unsymmetrically mixed, not harmoniously blended. There is no apparent tendency to hermaphroditism. This unsymmetrical mixture resembles that occasionally seen in the male of *Ocneria dispar* L., where also, according to Standfuss, the patches of the female pattern that sometimes appear do not betoken organic hermaphroditism.

3. *P. eremita* ♂ and *P. monacha* ♀. This was a natural pairing found by Standfuss in Silesia. The result was entirely different from that of the former cross, inasmuch as the issue contained every kind of transition between the two parent forms, while a few even transcended the male parent in darkness.

Thus the two specimens of so-called *eremita* in this and the former observation, though externally so much alike, possessed entirely different properties in regard to the power of transmission to descendants. Standfuss explains the apparent contradiction thus: The first *eremita* was a true sport or aberration, and in its case the rule held good as usual. The second, also called "*eremita*" (which did not show the *eremita* characters so well as some of its own offspring), was a link in the chain leading by slight variations to a darker and presumably better protected form of *P. monacha*, which, under the influence of natural selection, is gradually developing itself in certain parts of the range

of 195 individuals are known for three generations, seems, like that of *Aglia tau* and its aberration *lugens* (*infra*, p. 199), to promise suitable data for the verification of Mr. Francis Galton's law of heredity. According to this law the sum of the ancestral contributions is expressed by the series $(0{\cdot}5) + (0{\cdot}5)^2 + (0{\cdot}5)^3 + \ldots (0{\cdot}5)^n$, each term standing for a generation. See Galton, *Natural Inheritance*, 1889, p. 134, and "Average Contribution of each Several Ancestor to the Total Heritage of the Offspring," *Proc. Roy. Soc.*, 1897, pp. 401-413.

of the species. It took rank therefore not as an aberration, but rather as a member of a local race, and with this its behaviour accorded.[1]

4. *Aglia tau* L. ♂ and *do.* ab. *lugens* Stdfs. Like the dark aberration *zatima* of *S. lubricipeda*, the dark *Aglia tau* (called by Standfuss ab. *lugens*) exists in several degrees of development, from the "ab. *fere nigra*" of Thierry-Mieg to the "ab. *nigerrima*" of Bang-Haas. All these different stages of darkening have been obtained by Standfuss from pairings between *A. tau* and ab. *lugens*, but no transitional form between the normal *A. tau* and ab. *fere nigra* has ever been so produced.

In 1888 Standfuss crossed males of ab. *lugens*, which had been interbred for two generations, with females of the normal *A. tau*. In 1889 *lugens* derived from these were employed in the following pairings: *lugens* ♂ and *tau* ♀; *tau* ♂ and *lugens* ♀; *lugens* ♂ and *do.* ♀. The specimens of *A. tau* were in each case of different ancestry from the *lugens* stock. In 1890 two separate pairings were procured of *lugens* ♂ and ♀ from the third of the above broods, so that the perfect insects emerging in 1891 had both parents and all grandparents of the *lugens* type. The results of these experiments were curious, and should be studied in the original account (*Handbuch*, p. 312). Here it may be briefly stated that of the 1889 pairings, the first two (*lugens* ♂ and *tau* ♀; *tau* ♂ and *lugens* ♀) produced about 50 per cent. of each form.[2]

The third (*lugens* ♂ and ♀) gave 36 per cent. of *tau* to

[1] Compare the result of crossing *C. dominula* with the local race *persona*, and see especially Standfuss's figures, *Op. cit.*, Taf. V. Compare also the case of *A. betularia* and its aberration *doubledayaria* (*inf.*, p. 201), which is strikingly analogous with that of *P. monacha*.

[2] In both of these reciprocal crosses there is a slight preponderance of forms resembling the *male* parent—in the first instance *lugens*, in the second *tau*. This case is fairly analogous with that of the breed of Basset hounds lately investigated by Mr. Francis Galton ("The Average Contribution of each Several Ancestor," etc., *Proc. Roy. Soc.*, 1897, pp. 401-413), where the reciprocal crosses of two colour-varieties show a male prepotency in the proportion of about six to five (*loc. cit.*, Table I., p. 409). As in the instance of *tau* and *lugens*, there are no intermediate forms between

64 per cent. of *lugens*. In the 1890 broods, all of whose ancestors were *lugens* for two generations, the proportion of *tau* had fallen to a little over 11 per cent. in one and a little under the same figure in the other. In each of the five cases about twice as many females as males were of the *tau* form. Hence, as Standfuss puts it, it is more difficult to transform the female of *Aglia tau* than the male.[1]

5. *Grammesia trigrammica* Hufn. ♂ and *do.* ab. *bilinea* Hb. ♀. The female *bilinea*, taken by Gross at Garsten in Austria, laid eggs of which the male parent was presumably a normal *G. trigrammica*. Of the sixty-seven perfect insects that resulted, thirty-eight were *trigrammica* and twenty-nine *bilinea*. There were no intermediates.

6. *Angerona prunaria* L. ♂. and *do.* ab. *sordiata* Fuessl. ♀. This cross, procured by Zeller, gave seventeen *prunaria* and fourteen *sordiata*.

7. *A. prunaria* ab. *sordiata* ♂ and *A. prunaria* ♀. This cross, also obtained by Zeller, gave eighty-four of *prunaria* to sixty-eight of *sordiata*, *i.e.*, as in the reciprocal cross, about 55 per cent. of the type and 45 per cent. of the aberration. In neither of these cases were there any intermediates.

8. *A. prunaria* ab. *sordiata* ♂ and ♀. Among a large brood reared from the eggs of a pair of normal *A. prunaria*, there appeared three males and two females of the aberration *sordiata*. From a pair of these Standfuss obtained thirteen *prunaria* (three ♂ and ten ♀) and forty-two *sordiata* (twenty-four ♂ and eighteen ♀). Again there were no transitional forms.

9. *Amphidasis betularia* L. ♂ and *do.* ab. *doubledayaria* Mill. ♀. A female *doubledayaria* found by Steinert near

the "tricolour" and "non-tricolour" hounds, though there are different degrees of development of black in the "tricolours" which may be comparable with the range of variation between "*fere nigra*" and "*nigerrima*" in *lugens*. It is noticeable that in the case of *S. lubricipeda* and *do.* ab. *zatima* (*supr.* p. 197), the reciprocal crosses do not afford evidence of male prepotency. The numbers, however, are small.

[1] Compare the result of the cross between *P. monacha* ♂ and ab. *eremita* ♀. Here the typical *monacha* form was retained by twenty females and only two males.

Dresden produced seventy-five *betularia* (thirty ♂ and forty-five ♀) and ninety *doubledayaria* (thirty-four ♂ and fifty-six ♀). The male parent was doubtless an ordinary *betularia*. Two of the examples classed as *betularia* were darker than the normal, but otherwise no transitional forms occurred. Standfuss is of opinion that even these two need not be regarded as owing their darker coloration to the cross, for it is well known that *A. betularia*, like *P. monacha*, is undergoing a gradually increasing melanism, which is probably protective, in many parts of its area of distribution. The extreme aberration *doubledayaria*, which thirty years ago was known only from Great Britain, has now appeared in Westphalia, the Rhine Provinces, Hanover, Gotha, and lastly in Dresden and Silesia. In several of these places it is becoming more and more common, and in at least some of them it is found side by side with the darkening forms of *A. betularia*, which, though of different nature and origin from the sport *doubledayaria*, are no doubt being preserved and brought up to its level (in aspect) under the influence of natural selection.[1]

10. *Boarmia repandata* L. ♂ and *do.* ab. *conversaria* Hb. ♀. A large brood raised from the eggs of a pair of normal *B. repandata* contained three males and one female of the aberration *conversaria*. This female, which was paired with a wild male *B. repandata*, produced twenty-eight *repandata* (of which ten were males and eighteen females) and six *conversaria* (four being males and two females). The majority of the larvæ died during the winter. Here again intermediate forms were entirely absent.[2]

From the above experiments in the pairing of normal forms with aberrations and local races, performed or recorded by Standfuss, he arrives at the following conclusions :—

[1] Compare the facts with regard to *Papilio Sarpedon* given by Jordan, ("On Mechanical Selection," *Nov. Zool.*, 1896, p. 431) in illustration of the position that "abnormal varieties show distinctly the directions in which a species is able to develop". Compare also the result of an experiment cited by Tutt, "Melanism," 1891, p. 15.

[2] Compare the result of an observation by Mr. South, who raised hybrids from the same two forms in 1883 (*Proc. Ent. Soc. Lond.*, 1887, p. xliv.).

1. When the normal form of a species (Grundart) is crossed with a gradually formed local race of the same species, the result is a series of intermediate forms.

2. When the normal form is crossed with a sporadic aberration, the result in many cases is that the issue divides itself sharply between the normal form and the sport, intermediate forms being absent.

Hence, according to Standfuss, the process of species-formation must be gradual; for when two distinct species are crossed, the issue does not split up into the two parental forms as in the case when one parent is a suddenly formed aberration. On the contrary, the behaviour of the issue of two distinct species is very similar in kind to that of a species crossed with a local race or variety which is being gradually established by the accumulation of slight changes. It would seem therefore that although an aberration or sport may be perpetuated by inheritance, it can never acquire distinct specific rank. No doubt however it may, if selected, eventually replace the original form of the species.

To the foregoing considerations it may here be added that these sporadic colour-aberrations seem to have many points of resemblance with the colour-varieties in domestic animals, such as the "lemon-and-white" and "tricolour" of the Basset hounds referred to above (p. 199, note), or the well-known tortoiseshell, tabby and black of cats. The fact that these domestic varieties exist side by side in the same race and even in the same litter, and that true intermediates are rare or absent, seems to suggest that they originally appeared as sports, and that their perpetuation has been ensured or favoured by artificial selection, just as, if Standfuss is right, the dark aberrations of *P. monacha* and *A. betularia* are being perpetuated and multiplied by natural selection. Finally, the well-known case of the "otter sheep" (Darwin, *Variation of Animals and Plants under Domestication*, 1868, vol. i., p. 100), where also intermediates are said to be absent, and other instances on record, show that the phenomenon of sharp division between types in the offspring is not confined to crosses between colour-varieties of the same race, but occurs in other kinds of aberration as well.

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MODIFICATION AND VARIATION AND THE LIMITS OF ORGANIC SELECTION.

By Prof. HENRY F. OSBORN, Columbia University, New York and Prof. EDWARD B. POULTON, Oxford University, England.

(Abstract of Professor OSBORN'S paper.)

ORGANIC selection is the term proposed by Prof. Mark Baldwin and adopted by Prof. C. Lloyd Morgan and the author, for a process in nature which is believed to be a true cause of definite or determinate evolution in certain stuctures. The hypothesis is briefly as follows: that ontogenetic adaptation is a very profound character. It enables animals and plants to survive very critical changes in their environment. Thus all the individuals of a race are similarly modified over such long periods of time that very gradually congenital or phylogenetic variations which happen to coincide with the ontogenetic adaptive variations, are selected. Thus there would result an apparent, but not real transmission of acquired characters.

This hypothesis, if it has no limitations, brings about a very unexpected harmony between the Lamarckian and Darwinian aspects of evolution, by mutual concessions upon the part of the adherents of both theories. While it abandons the transmission of acquired characters, it places individual adaptation first, and fortuitous variation second, as Lamarckians have always contended, instead of placing survival conditioned by fortuitous variations first and foremost, as selectionists have contended.

This hypothesis has been endorsed by Alfred Wallace. It appears to the author, however, that it is subject to limitations and exceptions which go far to nullify its universal application. This is especially seen in the fact that the law of Determinate Variation is observed to operate with equal force in certain structures, such as the teeth, which are not improved by individual use or exercise, as strongly as in structures which are so improved. A very large class of determinate variations in other stationary characters, such as the inner parts of the skull, also remain unexplained. The author's studies of teeth in a great many phyla of Mammalia in past time have convinced him that there are fundamental predispositions to vary in certain directions; that the evolution of the teeth is marked out beforehand by hereditary influences which extend back hundreds of thousands of years. These predispositions are aroused under certain exciting causes and the progress of teeth development takes a certain form converting into actuality what has hitherto been potentiality.

This paper was discussed by Dr. Theodore Gill and Prof. Edward D. Campbell.

(Abstract of Professor POULTON'S paper.)

IT must be admitted that the adaptation of the individual to its environment during its own lifetime possesses all the significance attributed to it by Professor Osborn, Professor Baldwin, and Professor Lloyd Mor-

gan. These authorities justly claim that the power of the individual to play a certain part in the struggle for life may constantly give a definite trend and direction to evolution, and that although the results of a purely individual response to external forces are not hereditary, yet indirectly they may result in the permanent addition of corresponding powers to the species; — inasmuch as they may render possible the operation of natural selection in perpetuating and increasing those inherent hereditary variations which go further in the same direction than the powers which are confined to the individual.

. . . .

Professor Osborn's metaphor in opening this discussion puts the matter quite clearly and will be at once accepted by all Darwinians. If the human species were led by fear of enemies or want of food to adopt an arboreal life, all the powers of purely individual adaptation would be at once employed in this direction and would produce considerable individual effects. In fact the adoption of such a mode of life would at first depend on the existence of such powers. In this way natural selection would be compelled to act along a certain path, and would be given time in which to produce hereditary changes in the direction of fitness for arboreal life. These changes would probably at first be chiefly functional, as Mr. Cunningham has argued (in the Preface to his Translation of Eimer). On these principles we can understand the arboreal kangaroo (Dendrolagus) found in certain islands of the Malay Archipelago, which is apparently but slightly altered from the terrestrial forms found in Australia. Professor Osborn has alluded to the arboreal habits said to have been recently acquired by Australian rabbits; these and the similar modification in habits of West Indian rats, are further examples of individual adaptive modification which may well become the starting point (in the sense applied above) of specific variation led by natural selection in the definite direction of more and more complete adjustment to the necessities of arboreal life. Although this conclusion seems to me to be clear and sound, and the principles involved a substantial gain in the attempt to understand the motive forces by which the great process of organic evolution has been brought about, I cannot admit that the importance of natural selection is in any way diminished. I do not believe that these important principles form any real compromise between the Lamarckian and Darwinian positions, in the sense of an equal surrender on either side, and the adoption of an intermediate position. The surrender of the Lamarckian position seems to me complete, while the considerations now advanced only confer added significance and strength to the Darwinian standpoint.

. . . .

I propose to devote the remainder of the time at my disposal in support of the conclusion that the power of individual adaptation possessed by the organism forms one of the highest achievements of natural selection and cannot in any true sense be considered as its substitute. Professor Baldwin and Prof. Lloyd Morgan thoroughly agree with this conclusion

and have enforced it in their writings on the subject of organic selection. The contention here urged is that natural selection works upon the highest organisms in such a way that they have become modifiable, and that this power of purely individual adaptability in fact acts as the nurse by whose help the species, as the above named authorities maintain, can live through times in which the needed inherent variations are not forthcoming, but in part acts also as a substitute, not indeed for natural selection, but for the ordinary operation by which the latter produces change. In this latter case natural selection acts so as to produce a plastic adaptable individual which can meet any of the various forces to which it is likely to be exposed by producing the appropriate modification and this, it is claimed, is in many instances more valuable than the more perfect, but more rigid, adjustment of inherent variations to a fixed set of conditions.

. . . .

A good example of the eminent advantages of adaptability in many directions, over accurate adjustment in fewer directions, is to be found in a comparison between the higher parts of the nervous system in insects and birds. The insect performs its various actions instinctively and perfectly from the first; it is almost incapable of education and of modifying its actions as the result of the observation of the effects of some new danger. It would appear that the introduction of the electric light can only affect the insects which are most attracted to it, by the gradual operation of natural selection. In the clothes-moths, which infest our houses, we may see an example of this; for these insects seem to be comparatively indifferent to light. Birds, on the other hand, have the power of learning from experience, of reasoning from the results of observation. At first terrified by railway trains they learn that they are not dangerous, and cease to be alarmed; while the effect of firearms results in their increased wariness.

If this view of individual adaptability as due to natural selection be not accepted it may be supposed that the individual modifications are due either to the direct action of the external forces, or to the tendencies of the organism. But it is impossible to understand how the mechanical operation of such forces as pressure, friction, stress, etc., continued through a lifetime, could evoke useful responses, or why the response should just attain and then be arrested at a level of maximum efficiency. The other supposition, that organisms are so constituted that they *must* react under external stimuli by the production of new, useful characters, or the useful modification of old ones, seems to me to be essentially the same as the old "innate tendency toward perfection" as the motive cause of evolution — a conception which is not much more satisfactory than special creation itself. The inadequacy of the view is clearly shown when we consider that the external forces which awake response in an organism generally belong to its inorganic (physical or chemical) environment, while the usefulness of the response has relation to its organic environment (enemies, prey, etc.). Thus one set of forces supply the stimuli which evoke a response to another and very different set of forces. We can therefore

accept neither of the suggestions which have been offered. Useful individual modifications are not directly due to the external forces and are not due to the inherent constitution of the organism.

. . . .

The only remaining hypothesis is that which I have already mentioned — the view that whenever organisms react adaptively under external forces they do so because of special powers conferred on them by natural selection. This hypothesis will, it seems to me, meet and satisfactorily explain all the facts of the case — whether employed as a preparation or as a substitute for hereditary variations accumulated by Natural Selection.

In closing the discussion, in reply to Professor Poulton, Professor Osborn stated that natural selectionists were wont to embrace every new process discovered in nature in the old comprehensive power of selection; but that he believed that plastic adaptation had not been acquired by Natural Selection but was a fundamental property of protoplasm.

IV. *Notes on American and other Tingitidæ, with Descriptions of two new Genera and four Species.* By George Charles Champion, F.Z.S.

[Read December 1st, 1897.]

Plates II, III.

The following notes were made while studying the numerous Central-American species of this family of Heteropterous insects (*cf.* Biol. Centr.-Am., Rhynchota, ii, pp. 1-48). Most of the corrections in the synonymy of various South-American species have already been noted by me, but as they may be overlooked in a work dealing with a limited fauna, they are here repeated. Professor Poulton having kindly lent me the small but valuable collection of American Tingitidæ belonging to the Oxford Museum—mostly from the Antillean island of St. Vincent, or from the Amazons (*Bates*),—some remarks on these are added, with descriptions of one new genus and three species. Herr A. Handlirsch, also, has sent me for examination a large number of American Tingitidæ belonging to the Vienna Museum: amongst these, there are specimens of an interesting new genus, from Lower California, allied to *Acalypta*, Westw., a description of this insect being included in the present paper. The opportunity is taken, too, of figuring a number of the types of Stål's South-American species, very many of which, including those of all his numerous American genera, have been communicated by Dr. Aurivillius of the Stockholm Museum. The two South-American species of *Monanthia* described by Mr. Distant (Ann. Soc. Ent. Belg. 1888, p. lxxxiii) are also figured.

Phyllotingis, Walker.

This genus (= *Alyattes*, Stål, 1865, and *Euloba*, Uhler, 1884), based upon a single species from the Amazons, *P. arida*, Walk. (= *eximia*, Hagl., and *pallida*,

Uhler), is incorrectly referred to the Tingitidæ: it belongs to the Aradidæ. The name *Alyattes* being preoccupied, Dr. Bergroth [Verh. zool.-bot. Ges. Wien, xxxvi, p. 59 (1886)] has substituted *Phyllocraspedum* for it; Walker's name, published in 1873, must however be retained.* His species will stand as *Phyllotingis eximia*, Haglund's name having five years' priority. Two others are now known.

SOLENOSTOMA, Signoret.

Coleopterodes, Philippi, Stett. ent. Zeit. xxv, p. 306 (1864).

This genus includes a single species, *S. liliputianum*, Sign. (= *Coleopterodes fuscescens*, Philippi), from Chili. There are two specimens of it in the Oxford Museum.

DOLICHOCYSTA, gen. n.

Rostrum extending to the meso-metasternal suture. Rostral groove uninterrupted, narrow and parallel on the pro- and mesosternum, closed in front, the buccal laminæ long and very prominent. Intercoxal portion of the metasternum broad and transverse. Antennæ slender, widely separated at the base. Head without spines, the eyes small. Pronotum tricarinate, with broad, rounded, closely reticulated membranous margins, and a long decurved, anteriorly prominent hood, the triangular posterior portion largely developed, acute at the tip. Elytra short, broad oval, a little longer than the abdomen; discoidal area large, occupying more than two-thirds of the length of the elytra, raised externally, and surrounded by prominent nervures, the outer (median) nervure subfoliaceous; subcostal area about as wide as the costal; costal area of uniform width from the base to near the apex, biseriate almost to the tip. Orifice not visible. Legs very slender.

This genus bears a general resemblance to *Acalypta*, Westw. (= *Orthostira*, Fieb.); but differs from it in the very prominent buccal laminæ, which close the rostral groove in front, the long, anteriorly prominent, decurved pronotal hood, &c. It is perhaps best placed near *Corythaica*, Stål. The specimens described may perhaps belong to a brachypterous form; they are from the northern part of Lower California.

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* The antennæ are incorrectly described by Walker, the type having a very elongate basal joint

I. *Dolichocysta venusta*, sp. n. (Pl. II., figs. 1; 1a, profile.)

Broad oval, short, dull; fuscous, the pronotum with the areolæ at the sides in front and behind, the areolæ of the hood in part, the tip of the posterior process, and the three carinæ, a broad blackish patch on the median one excepted, more or less whitish and subhyaline; the elytra greyish, with a spot on the discoidal area before the apex, a patch on the costal area before the middle, and some spots or some of the nervures before and beyond it, black, the other portions of the costal area whitish and subhyaline with pale nervures, the nervures on the rest of the elytra blackish or fuscous; the antennæ testaceous, with the outer half of the apical joint black; the legs testaceous, the femora black or piceous in the middle. Antennæ with joints 1 and 2 stouter than the others, 2 much shorter than 1, 3 very slender and elongate, 4 lanceolate and pilose, about as long as 1 and 2 united. Pronotum closely punctured on the disc; the membranous margins with 3—4 rows of small areolæ; the median carina strongly, the two outer carinæ feebly, foliaceous, the latter sinuous and connected anteriorly with a layer of membrane which fills the space outside the base of the hood; hood extending beyond the head, narrowed and strongly curved downwards in front, rather widely reticulated. Elytra a little wider than the pronotum; discoidal, subcostal, and sutural areas (the margin of the latter excepted) closely reticulated; costal area slightly recurved, with larger areolæ, the two rows diminishing to one at the apex.

Length $2\frac{1}{3}$—$2\frac{1}{2}$, breadth $1\frac{1}{5}$—$1\frac{1}{4}$ millim.

Hab.—Lower California, Guadalupe (*Bilimek, in mus. Vind. Cæs.*).

Three examples, two of which are from Guadalupe, the other without definite locality. The insect is not included in Prof. Uhler's list of Hemiptera Heteroptera of Lower California [Proc. Calif. Acad. Sci. (2) iv, pp. 223-295 (1894)].

Corythucha, Stål.

Numerous closely allied American species belong to this genus. *Monanthia lucida*, Walk. (= *C. fuscigera*, Stål), and *Tingis spinosa*, A. Dugès, both from Mexico, also appertain here. Stål's type of *C. fuscomaculata*, from Brazil, is figured on Plate II, fig. 2. This last-mentioned insect is extremely like *C. fuscigera*, Stål, but it appears to have the apical margin of the elytra less rounded, the inner portion being oblique.

Tingis, Fabr.

Stål (Enum. Hemipt. iii, p. 123) uses the name *Stephanitis* for the European *Tingis pyri*, Fabr., and *T. oberti*, Kol., and a very dissimilar South-American form, *S. mitrata*, Stål, but this course has not been followed by Lethierry and Severin. The American species ought to be separated, and the name *Stephanitis* could be retained for it. Stål's type is figured on Plate II, figs. 3, 3*a*.

It may be here noted that the insect figured in Cuvier's Règne Animal, Ins., Atlas, ii, pl. 91, figs. 5, 5*a*, *b*, under the name *Tingis cristata*, Panz., is evidently referable to *T. pyri*, Fabr. It has nothing to do with Panzer's species.

Leptobyrsa, Stål.

The type of this genus is *L. steini*, Stål, from Rio Janeiro. It is figured on Plate II, fig. 4. Two others have been described by Berg from Buenos Ayres and five by myself from Central America.

Gargaphia, Stål.

This genus seems to be well characterised by the prominent transverse sinuous ridge between the meso- and metasternum, the cordate intercoxal portion of the metasternum being surrounded at the sides and in the front by a continuous membranous ridge. The species are all American.* Stål's type of *G. trichoptera*, from Bogota, Colombia, is figured on Plate II, fig. 5.

Corythaica, Stål.

Typonotus, Uhler, Proc. Zool. Soc. Lond. 1893, p. 716.

The characters of this genus were taken by Stål and Uhler from the same species, *C. monacha*, Stål (= *Tingis cyathicollis*, Costa, and *Typonotus planaris*, Uhler), the type of *C. monacha* being from Rio Janeiro and that of *T. planaris* from the Island of St. Vincent. Numerous specimens of the species are contained in the Oxford Museum. Stål's type has been communicated by Dr.

* *Tingis formosa*, Göldi, from Pará, probably belongs here or to *Leptostyla*, Stål.

Aurivillius. The insect has been beautifully figured by A. Costa. The second known species of the genus, *C. carinata*, Uhler, is from the Island of St. Vincent, and it has also been found in Guatemala by myself.

PACHYCYSTA, gen. n.

Rostrum reaching the first ventral suture. Rostral groove subparallel, uninterrupted, closed in front, the buccal laminæ not prominent, the meso- and metasternal laminæ slightly converging behind. Antennæ pilose, distant at the base, with moderately long, slender joints, 1 and 2 stouter than 3, 1 a little longer than 2, (4 broken off) Head with five short decumbent spines, very short, obtuse antenniferous tubercles, and an oblong, smooth, convex prominence in front. Pronotum with a very large, oval, anteriorly truncate hood, three foliaceous carinæ, and very broad, shell-like, incurved membranous margins. Elytra oval, rounded at the tip ; discoidal and subcostal areas closely, the costal and sutural areas more widely, reticulated, the costal area very broad, with three or fours rows of hyaline areolæ, the discoidal area extending to the middle and surrounded by prominent nervures. Orifice visible. Nervures of the pronotal processes and elytra stout, thickly pilose.

The single species from which the above characters are taken is perhaps nearest allied to the monotypic genus *Megalocysta*, Champ. ; but differs from it in having the pronotum strongly tricarinate, with the membranous margins greatly extended, vertical, and shell-like, and the reticulation of the elytra and of the membranous portions of the pronotum very much closer, &c. It cannot be included in *Leptostyla* or any of the other genera characterized by Stål.

Pachycysta diaphana, sp. n. (Pl. II, figs. 6, 6*a*.)

Body ferruginous, the integument testaceous, the areolæ of the elytra and pronotal processes more or less hyaline, the nervures and the costal margin thickly clothed with very short pallid hairs ; the legs and antennæ ferruginous. Pronotum with the three carinæ strongly foliaceous, each with a row of transverse hyaline areolæ, the median carina angularly raised anteriorly, the outer carinæ curved inwards and partly covered by the hood ; the hood extending to about the middle, rather closely reticulated ; the membranous shell-like margins rounded externally, with numerous small areolæ ; the triangular posterior portion large, and, like the disc, closely

reticulated. Elytra with the subcostal area biseriate; the broad costal area with three to four rows of rather small areolæ; the sutural area unequally reticulated. Wings extending to a little beyond the abdomen.

Length 3⅔, breadth nearly 2 millim. (♀.)

Hab. AMAZONS (*Bates, in Mus. Oxon.*).
One example.

LEPTOSTYLA, Stål.

Four American species were referred to this genus by Stål; one other has since been added by Berg, and seventeen by myself; *Monanthia lineifera*, Walk., from Brazil, also belongs to it.* It is one of the most characteristic genera of the family in Central America. Stål's type of *L. furcata*, from Rio Janeiro, is figured on Plate II, figs. 7, 7*a*.

LEPTOPHARSA, Stål.

This genus will probably prove to be inseparable from *Leptostyla*. Two species were known to Stål and a third has been added by myself, all from Tropical America. Stål's type of *L. elegantula*, from Colombia, is figured on Plate II, fig. 8.

LEPTODICTYA, Stål.

Five Tropical-American species were included by Stål under *Leptodictya*, and two others have been added by myself. *Monanthia tabida*, H.-S., from Mexico, also belongs here. Stål's type of *L. fuscocincta*, from Rio Janeiro, is figured on Plate II, fig. 9.

ACANTHOCHILA, Stål.

The type of this genus is *A. armigera*, Stål (= *spinuligera*, Stål), from Rio Janeiro, this species being now known to extend northwards to Southern Mexico. Two others have since been added by Buchanan White and Uhler respectively. *A. armigera* has been figured by me elsewhere.

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* The type of an allied species, *M. lanceolata*, Walk., from Brazil, is apparently lost, as it cannot now be found in the British Museum.

Leptocysta, Stål.

Stål's single species, *L. sexnebulosa*, from Rio Janeiro, is figured on Plate II, figs. 10, 10*a*.

Sphærocysta, Stål.

Of the two Brazilian species included in this genus, one, *S. globifera*, Stål, is figured on Plate II, figs. 11, 11*a*.

Amblystira, Stål.

Stål included in this genus a single species, *A. pallipes*, from Rio Janeiro, and four others have been added by myself. The type of *A. pallipes* is figured on Plate II, fig. 12.

Leptoypha, Stål.

The type of this genus is *Tingis mutica*, Say, from Texas. Two allied forms from Mexico and Guatemala have been figured and described by me elsewhere.

Tigava, Stål.

This genus was based upon a single species, *T. præcellens*, Stål, from Rio Janeiro; two others have been added by me from Central America. Stål's type is figured on Plate III, fig. 1.

Teleonemia, Costa.

Tingis, subgen. *Americia*, Stål, Enum. Hemipt. iii, p. 131.

Lasiaeantha, Lethierry et Severin, Cat. Hémipt. Hétéropt. iii, p. 18 (part.).

This appears to be the most characteristic genus of Tingitidæ in Tropical America, fourteen being known to me from Central America alone.

The types of Stål's species of *Teleonemia* have been communicated by Dr. Aurivillius, also those of *Tingis* (*Americia*) *albilatera* and *T.* (*Americia*) *limbata*. *T. albilatera*, as I have noted elsewhere, = *Tingis triangularis*, Blanch., Stål apparently not having seen Blanchard's figure. The types of the following species are figured on Plate III: *T.* (*Amauro-*

sterphus) morio, fig. 2; *T. validicornis*, fig. 4; *T. luctuosa*, fig. 5; *T. prolixa* (? = *elevata*, Fabr.), fig. 6; *T. belfragii*, fig. 8; also that of *T.* (*Americia*) *limbata*, fig. 10. A figure of *T. aterrima* is given, fig. 3, from a specimen from the Amazons in the Oxford Museum, Stål's type having the apical joint of the antennæ broken off.

Of *T. sacchari*, H.-S. and Stål, there are numerous specimens from the Island of St. Vincent in the Oxford Museum.

The two following species from the Amazons cannot be identified with any of the known members of the genus, and they are therefore treated as new.

Teleonemia longicornis, sp. n. (Pl. III, fig. 7.)

Elongate, narrow, dull; fusco-ferruginous, the spines on the head, and the margins, carinæ and hood of the pronotum testaceous, the triangular posterior portion of the latter yellowish; the elytra fuscous, with the base, the outer and inner margins of the sutural area, the costal margin, and the nervures of the costal area from a little beyond the middle to near the apex, testaceous, the areolæ of the latter for a similar distance, and also some of those along the apical margin, and two of the inner ones before the tip, hyaline; the antennæ ferruginous, the two basal joints and the apex of the third darker, the fourth joint black; the legs ferruginous. Head with decumbent spines; antennæ very elongate, about as long as the elytra, moderately stout, joint 2 slightly shorter than 1, 3 three times as long as 4, 4 pilose. Pronotum sharply tricarinate, and with a small, compressed, angularly projecting hood in front, the marginal carinæ moderately prominent, the interspaces coarsely, closely punctate. Elytra long, constricted beyond the middle, and slightly dilated at the apex, the apices bluntly rounded, the median nervure prominent; discoidal area with rather deeply impressed areolæ; subcostal area biseriate; costal area with a single row of transverse areolæ from about the middle onwards, becoming vertical and cariniform towards the base. Rostrum reaching the meso-metasternal suture.

Length 5, breadth $1\frac{1}{2}$ millim. (♂.)

Hab. AMAZONS (*Bates, in Mus. Oxon.*).

One example. This insect resembles Costa's figure of *T. funerea*, but has shorter, less parallel, and differently coloured elytra, the small pronotal hood more prominent in front, &c. Amongst the numerous species described by

Stål (the types of all of which are before me) it is perhaps nearest allied to *T. scrupulosa*, from which it may be separated by the very long and less distinctly pilose antennæ, the longer elytra, with glabrous discoidal area and the hyaline areolæ of the costal area not extending to the base, &c.

Teleonemia brevipennis, sp. n. (Pl. III, fig. 9.)

Moderately elongate, narrow, dull; blackish-fuscous, the spines on the head and the front of the pronotum obscure testaceous, the triangular posterior portion of the pronotum, and the hood in part, yellowish; the elytra fuscous, with the costal margin and the nervures of the costal area for some distance beyond the middle testaceous, the areolæ of the latter to near the apex hyaline. Head with decumbent spines; antennæ long and moderately stout, joint 2 considerably shorter than, and not so stout as, 1, 3 rather more than twice the length of 4, 3 and 4 clothed with very short hairs. Pronotum sharply tricarinate, and with a small, compressed, subangularly projecting hood in front, the marginal carinæ prominent, the interspaces coarsely, closely punctate. Elytra (when closed) suboval, comparatively short, rounded at the apex; discoidal area with deeply impressed areolæ, the nervure limiting it externally rounded and prominent; subcostal area biseriate; costal area rapidly widening beyond the middle, very narrow towards the base, with a single row of areolæ, increasing to two in the widest part, the areolæ small to about the middle and then becoming larger and transverse. Rostrum reaching the meso-metasternal suture.

Length $3\frac{3}{4}$, breadth $1\frac{1}{2}$ millim. (♀.)

Hab. Amazons (*Bates, in Mus. Oxon.*).

This species differs from all the *Teleonemiæ* known to me in the relatively short, somewhat oval elytra. The costal area is abruptly widened beyond the middle, and at the widest part there are two additional hyaline areolæ, there being thus two rows at this place. The wings extend beyond the abdomen. The insect approaches the *Tingis* (*Americia*) *limbata*, of Stål, which would be better placed in *Teleonemia*.

Eurypharsa, Stål.

The type of this genus is *Tingis nobilis*, Guér., from, Tropical South America, and *T. circumdata*, Blanch.,

belongs to the same species. There are two specimens of it in the Oxford Museum: one labelled "S. Amer., d'Orbigny, ex Mus. Jard. Plantes," this being, no doubt, one of Blanchard's types, which were from Chiquitos, Bolivia; and the other from the Amazons (*Bates*). A second species has been described by me from the State of Panama. Both have been figured.

Monanthia, Lep.

The four Tropical-American representatives of this genus known to me—*M. monotropidia*, Stål, *M parmata*, Dist., and *M. loricata*, Dist., and a new species described by me elsewhere—are closely allied.

Figures of Mr. Distant's species are here given on Plate III: fig. 11 being taken from *M. loricata*, and fig. 12 from *M. parmata*.

Explanation of Plates II and III.

[*See Explanation facing the* Plates.]

Explanation of Plate II.

Illustrating Mr. G. C. Champion's "Notes on American and other Tingitidæ."

Fig. 1, 1*a* *Dolichocysta venusta*, gen. et sp. n.

2 *Corythucha fuscomaculata*, Stål.

3, 3*a* *Stephanitis mitrata*, Stål.

4 *Leptobyrsa steini*, Stål.

5 *Gargaphia trichoptera*, Stål.

6, 6*a* *Pachycysta diaphana*, gen. et sp. n.

7, 7*a* *Leptostyla furcata*, Stål.

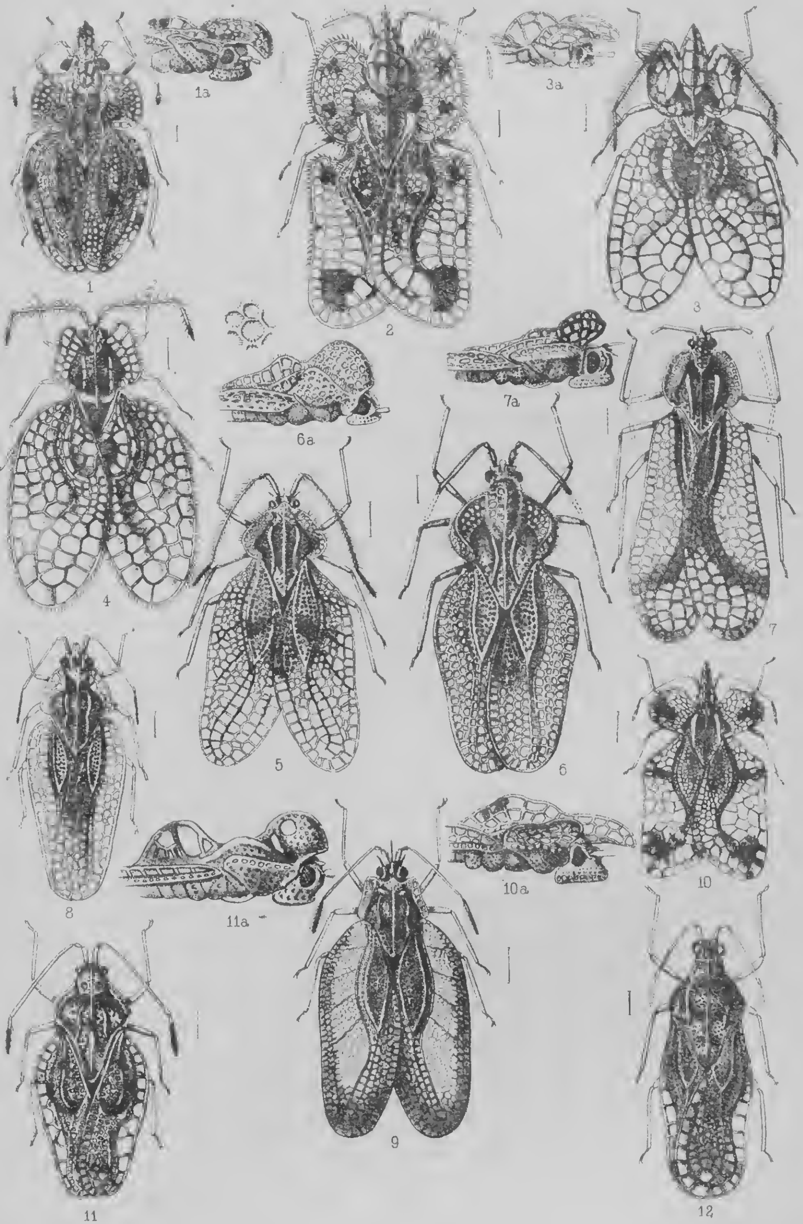
8 *Leptopharsa elegantula*, Stål.

9 *Leptodictya fuscocincta*, Stål.

10, 10*a* *Leptocysta sexnebulosa*, Stål.

11, 11*a* *Sphærocysta globifera*, Stål.

12 *Amblystira pallipes*, Stål.



Edwin Wilson Cambridge

American Tingitidae.

Explanation of Plate III.

Illustrating Mr. G. C. Champion's "Notes on American and other Tingitidæ."

Fig. 1. *Tigava pulchella*, Stål.

2. *Teleonemia* (*Amaurosterphus*) *morio*, Stål.

3. ,, *aterrima*, Stål.

4. ,, *validicornis*, Stål.

5. ,, *luctuosa*, Stål.

6. ,, *prolixa*, Stål.

7. ,, *longicornis*, sp. n.

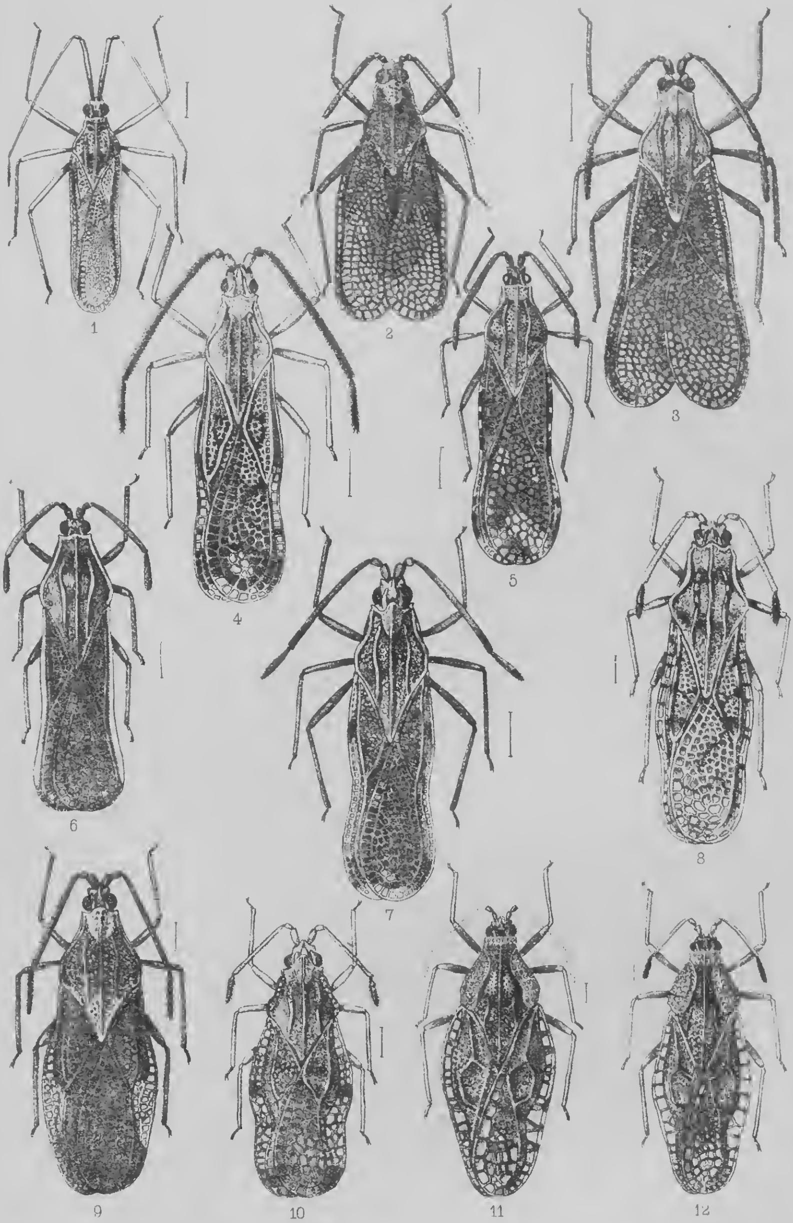
8. ,, *belfragii*, Stål.

9. ,, *brevipennis*, sp. n.

10. ,, (*Americia*) *limbata*, Stål.

11. *Monanthia loricata*, Dist.

12. ,, *parmata*, Dist.



Edwin Wilson Cambridge

American Tingitidæ

From the ANNALS AND MAGAZINE OF NATURAL HISTORY,
Ser. 7, Vol. i., *May* 1898.

Descriptions of some new Species of Syntomidæ, *chiefly in the Oxford Museum.* By HERBERT DRUCE, F.L.S. &c.

Pseudopompilia mimica, sp. n.

Female.—Primaries and secondaries brownish black: primaries shot with greenish blue beyond the cell and along the inner margin; a tuft of greenish-white scales at the base, the fringe black: secondaries with a small semihyaline spot at the base. The underside of both wings very similar to the upperside; the primaries with a reddish-brown streak at the apex and along the inner margin. The head, collar, tegulæ, thorax, abdomen, and legs black; the legs with a yellowish-white streak on the upperside; the antennæ black, with the shaft sordid white from the base to the middle.

Expanse 2 inches.

Hab. Amazons (*in the Hope Collection, Mus. Oxford*).

This very remarkable species closely resembles *Myrmecopsis vespa*, Herr.-Schäffer, also from the Amazon region.

Calonotos tripunctata, sp. n.

Male.—Primaries and secondaries black; a small green spot at the base and a green streak partly along the costal margin; an elongated white spot below the cell about the middle of the wing, and a rather large round white spot at the end of the cell nearer the apex: secondaries with a white spot on the middle of the costal margin. Underside very similar to the upperside; the costal margin of the secondaries streaked with green at the base. The head, antennæ, tegulæ, thorax, abdomen, and legs black; the abdomen striped from the base to the anus with three wide, greenish-white lines, one down the middle, and one on each side.

Expanse $1\frac{3}{4}$ inch.

Hab. Trinidad (*Lowsley, in Mus. Druce*).

Calonotos chryseis, sp. n.

Female.—Primaries above dark golden green; underside much paler, with the veins black: secondaries black, with a few green scales in the cell; underside pale green, with black veins. Antennæ and front of the head black, with two small white spots between the eyes; palpi black. Collar golden green, edged with black and three small white dots, one in

the middle and one on each side; tegulæ black, golden green at the base; thorax golden green; abdomen black, with three white spots close to the base and three rows of golden-green spots extending from the base to the anal angle; legs black; the underside of the abdomen with a row of white spots.

Expanse 2 inches.

Hab. Bolivia (*in the Hope Collection, Mus. Oxford*).

This species somewhat resembles *Eupyra bacchaus*, Schaus.

Homœocera lophocera, sp. n.

Male.—Primaries and secondaries hyaline: primaries, the base, costal, outer, and inner margins broadly black; a rather wide black band crosses the wing at the end of the cell, extending from the costal margin to the anal angle; two small blue dots at the base of the wing: secondaries broadly edged with black from the apex to the anal angle; the veins of both wings black. The head, antennæ, tegulæ, thorax, part of the abdomen, and legs black; a large white spot on each side of the thorax and one at the base of each leg; the last three segments of the abdomen and the anal tuft orange-red.

Expanse $2\frac{1}{4}$ inches.

Hab. Brazil (*in the Hope Collection, Mus. Oxford*).

Homœosoma stictosoma, sp. n.

Female.—Primaries and secondaries yellowish hyaline, the veins all black; primaries, the base black, the apex broadly black, the outer and inner margins black: secondaries edged with black from the apex to the anal angle, where it is broadest. The head, antennæ, thorax, abdomen, and legs black; a white spot on each side of the head, a metallic-blue spot on both the tegulæ; a white spot at the base of the thorax; two white and two blue dots on the first segment, and a central row of four white spots down the abdomen, also a row of white spots on each side of the abdomen.

Expanse 2 inches.

Hab. Colombia (*Chesterton, in the Hope Collection, Mus. Oxford*).

Trichura mathina, sp. n.

Male.—Primaries and secondaries yellowish hyaline; the outer and part of the inner margin edged with black; the veins yellow: secondaries edged with black from the apex to

the anal angle; the end of the cell black. The head, collar, tegulæ, and thorax black, the collar and tegulæ edged with yellow; the base of the thorax and the first and third segments of the abdomen yellow; the abdomen black; antennæ yellow-black near the base; the legs brownish yellow.

Expanse $1\frac{3}{4}$ inch.

Hab. Amazons, Pará (*Bates, Mus. Druce*).

This species is allied to *T. aurifera*, Butler.

Sarosa xanthobasis, sp. n.

Female.—Primaries and secondaries hyaline; the veins, costal margin, outer and inner margins edged with black, the apex broadly black: secondaries edged with black. The head, antennæ, and palpi black, the front of the head and the collar metallic blue; the thorax, tegulæ, abdomen, and hind legs bright chrome-yellow, the first and second pair of legs brownish black; the anal segments of the abdomen bluish black.

Expanse $2\frac{3}{10}$ inches.

Hab. Ecuador (*in the Hope Collection, Mus. Oxford*).

Mallodeta sanguipuncta, sp. n.

Male.—Primaries and secondaries hyaline; the veins black; the base, apex, outer and inner margins broadly black, a wide black band at the end of the cell: the secondaries edged with black from the apex to the base. Antennæ black, tipped with white on the upperside; the head, collar, tegulæ, thorax, abdomen, and legs black; two small spots at the back of the head, two at the base of the abdomen, and a row on each side white; the tegulæ edged with red; two red spots at the base of the abdomen, and two on the third segment somewhat indistinct.

Expanse 2 inches.

Hab. Paraguay (*in the Hope Collection, Mus. Oxford*).

Mesothen ignea, sp. n.

Male.—Primaries and secondaries hyaline, the veins all black; the apex of the primaries broadly bordered with black; the outer and inner margins edged with black: secondaries with the apex, outer and inner margins edged with black. The head, antennæ, palpi, and legs black; the collar, tegulæ, thorax, and abdomen dark chrome-yellow; the tegulæ spotted with black and a central black spot on each segment of the abdomen, the first three being the largest.

Expanse $1\frac{7}{10}$ inch.

Hab. Merida (*in the Hope Collection, Mus. Oxford*).

Phœnicoprocta metachrysea, sp. n.

Male.—Primaries and secondaries hyaline, the veins, costal margin, apex, outer and inner margins of both wings black. The head, antennæ, palpi, thorax, abdomen, and legs black ; front of the head metallic blue, the collar and tegulæ edged with blue, a central row of greyish-white spots on the abdomen, the anal segments and anal tuft yellow.

Expanse $1\frac{1}{4}$ inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Urolosia opalocincta, sp. n.

Male.—Primaries and secondaries hyaline ; the veins all black ; the costal, outer, and inner margins narrowly edged with black, widest at the anal angle: secondaries broadly bordered with black from the apex to the anal angle. The head, antennæ, palpi, collar, tegulæ, thorax, abdomen, and legs black ; the collar, tegulæ, and base of the primaries irrorated with a few metallic-green scales ; the second and third segments of the abdomen opalescent white, more so in the female than the male ; the anal tuft black.

Expanse $1\frac{3}{4}$ inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Herea xanthogaster, sp. n.

Male.—Primaries and secondaries brownish hyaline, with the veins and margins all black. The head, antennæ, thorax, abdomen, and legs all black ; the underside of the abdomen from the base to the anus bright chrome-yellow.

Expanse 1 inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Chrysostola fulvisphex, sp. n.

Male.—Primaries and secondaries hyaline, the veins brownish black : primaries, the costal and inner margins yellowish brown, the apex and outer margin edged with black : secondaries edged with black. Antennæ black ; the head, thorax, and abdomen yellowish brown, the anal half of the abdomen the darkest ; the collar and tegulæ black, edged with yellow ; the legs yellowish brown.

Expanse $1\frac{1}{10}$ inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Chrysostola sanguiceps, sp. n.

Male.— Primaries and secondaries hyaline: primaries broadly black at the apex, the outer and inner margins black, the veins black: secondaries edged with black from the apex to the anal angle, the veins yellow. The head, thorax, and basal half of the abdomen chrome-yellow, the anal half of the abdomen black; antennæ black; legs chrome-yellow.

Expanse 1 inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Paramya picta, sp. n.

Male.—Primaries semihyaline, the base and partly along the inner margin chrome-yellow, the apex broadly brownish black; a large black spot at the end of the cell, beyond which the wing is crossed by a rather indistinct pale yellow band; a small black streak on the inner margin close to the anal angle: secondaries chrome-yellow, the apex black. The head, antennæ, last three segments of the abdomen, and legs black; the thorax and abdomen chrome-yellow.

Expanse 1 inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Cosmosoma orathidia, sp. n.

Male.—Primaries and secondaries hyaline: primaries, the base, apex, outer and inner margins broadly black; a wide zigzag black band crosses the wing at the end of the cell from the costal margin to the anal angle: secondaries, the costal, outer, and inner margins edged with black. The veins of both wings black. The head, palpi, antennæ, thorax, abdomen, and legs black; the tegulæ black, edged with metallic blue; a large red spot on both sides of the abdomen at the base and a row of metallic-blue spots extending from the base to the anus on each side.

Expanse $1\frac{3}{10}$ inch.

Hab. Nicaragua, Chontales (*T. Belt, in the Hope Collection, Mus. Oxford*).

Histiæa glaucozona, sp. n.

Male.—Primaries brown, slightly shaded with pink in the cell; two minute blue dots at the end of the cell, beyond which is a very indistinct brownish-white band, similar in shape to the yellow band on the primaries of *H. amazonica*: secondaries brown, with a large square-shaped red spot beyond the

middle. Underside: primaries brown, bright pink in the cell, two small spots beyond and one large spot at the anal angle cream-colour; the spot on the secondaries is quite small and slightly reddish in colour. The head, antennæ, collar, tegulæ, thorax, abdomen, and legs brown; a row of metallic-blue spots on each side of the abdomen.

Expanse $2\frac{1}{2}$ inches.

Hab. Amazons (*in the Hope Collection, Mus. Oxford*).

This species is closely allied to *H. amazonica*, Butler.

Cyanopepla obscura, sp. n.

Male.—Primaries and secondaries dull brown, a small red spot and a metallic-green dot close to the base of the primaries and a small red spot on the costal margin of the secondaries near the apex; on the underside both wings are shot with bright metallic blue from the base to beyond the middle. The head, antennæ, thorax, and abdomen black, the collar metallic blue, each segment of the abdomen edged with metallic-blue scales; legs black.

Expanse $1\frac{1}{2}$ inch.

Hab. Peru (*in the Hope Collection, Mus. Oxford*).

Neacerea albiventus, sp. n.

Male.—Primaries and secondaries black: primaries with a small, transverse, white band about the middle, not reaching either margin: secondaries, the inner margin broadly greyish white; the fringe white at the apex of the primaries. Underside very similar to the upperside, but with the marking much whiter. The head, antennæ, collar, tegulæ, and thorax black; abdomen above dark glossy blue, on the underside white. Legs black above, white on the underside.

Expanse $1\frac{1}{4}$ inch.

Hab. South Brazil, Minas Garaes (*Rogers, in the Hope Collection, Mus. Oxford*).

Neacerea dizona, sp. n.

Male.—Primaries black, crossed by two semihyaline bands, neither of which extends to the margins of the wing; the first band before the end of the cell, the second beyond nearer the apex: secondaries hyaline, broadly bordered with black from the apex to the anal angle. The head, antennæ, palpi, tegulæ, thorax, abdomen, and legs black; collar red; the underside of the thorax and abdomen white.

Expanse $1\frac{3}{10}$ inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Loxophlebia postflavia, sp. n.

Male.—Primaries and secondaries hyaline, the veins all black: primaries, the base and apex broadly black, the outer and inner margins edged with black: the secondaries edged with black from the apex to the anal angle. The head, antennæ, thorax, and abdomen black; the three anal segments of the abdomen sordid yellow; the legs black.

Expanse $1\frac{1}{10}$ inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Lymire strigivenia, sp. n.

Male.—Primaries smoky black, the veins rather darker: secondaries hyaline dusky black along the costal margin, and broadly so along the inner margin. The head, antennæ, palpi, collar, tegulæ, thorax, abdomen, and legs black.

Expanse 1 inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

Psilopleura polia, sp. n.

Male.—Primaries and secondaries whitish hyaline: primaries, the base of the cell, a spot at the end of the cell, the apex, anal angle, and inner margin shaded with dark and light brown, darkest along the inner margin: secondaries edged with brown. The head and thorax pale brown; antennæ pale brown, tipped with white; tegulæ dark brown, with a pale brown streak down the middle; abdomen black above, with the base and sides yellow; legs brown.

Expanse $1\frac{1}{2}$ inch.

Hab. Espiritu Santo (*in the Hope Collection, Mus. Oxford*).

Teucer albapese, sp. n.

Male.—Primaries and secondaries hyaline, the veins all black; a large spot at the end of the cell black; the apex, outer and inner margins broadly black, the fringe at the apex white: secondaries, the costal, outer margin, and anal angle broadly black. The head, antennæ, thorax, abdomen, and legs black; the front of the head and the underside of the thorax and abdomen white.

Expanse 1 inch.

Hab. Cayenne (*in the Hope Collection, Mus. Oxford*).

This species is closely allied to *Anaphlebia caudatula*, Felder.

Holophæa cærulea, sp. n.

Female.—Primaries and secondaries uniformly dark bluish black. The head, antennæ, thorax, and legs black; abdomen dark glossy blue-black; the collar and the edges of the tegulæ bright red.

Expanse $1\frac{1}{4}$ inch.

Hab. Ecuador (*in the Hope Collection, Mus. Oxford*).

Atyphopsis roseiceps, sp. n.

Male.—Primaries and secondaries semihyaline greyish white, the veins all dark brown, the apex dark brown. The head, antennæ, collar, tegulæ, thorax, abdomen, and legs pale greyish brown; the top of the head and the fourth and fifth segments of the abdomen pale red; the anus black.

Expanse $1\frac{1}{4}$ inch.

Hab. S.E. Brazil, Rio Janeiro (*in the Hope Collection, Mus. Oxford*).

The specimen is in very poor condition and much faded.

ON A COLLECTION OF INSECTS AND ARACHNIDS MADE BY MR. E. N. BENNETT IN SOCOTRA, WITH DESCRIPTIONS OF NEW SPECIES.

BY

F. A. DIXEY, M.A., M.D., MALCOLM BURR, F.Z.S.,
AND THE REV. O. PICKARD-CAMBRIDGE, M.A., F.R.S., C.M.Z.S.

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On a Collection of Insects and Arachnids made by Mr. E. N. Bennett in Socotra, with Descriptions of new Species. By F. A. Dixey, M.A., M.D., Malcolm Burr, F.Z.S., and the Rev. O. Pickard-Cambridge, M.A., F.R.S., C.M.Z.S.

(Plates XXX. & XXXI.)

Contents.

I. LEPIDOPTERA, with Remarks on Local and Seasonal Forms in the Genus *Byblia* Hübn. By F. A. Dixey, M.A., M.D., Fellow of Wadham College, Oxford.

Mr. E. N. Bennett, a Fellow of Hertford College, Oxford, reached Socotra on December 17, 1896, in company with the

late Mr. Theodore Bent and Mrs. Bent. During their visit they traversed the island from Ghalansyah in the west to Ras Momi in the east, and thence, after a long circuit to the south-west, returned to Tamarida on the north coast. The party left the island on February 11th, 1897. Interesting personal accounts of the expedition will be found in the 'Nineteenth Century' for June 1897, by Mr. Bent; and in the volume of 'Longman's Magazine' for 1897, by Mr. Bennett. The whole of their sojourn in the island came within the period of the N.E. monsoon. Atmospheric conditions were persistently dry, especially on the plains; in the mountains there was a heavy dew every morning, which soon dried in the sun. Very little rain fell at any time, and the thermometer never sank below 60° F. Exactly 100 specimens of insects and arachnids, which are now in the Hope Museum, Oxford, were collected by Mr. Bennett.

The Rhopalocera consist of 52 specimens, belonging to 15 species, two of which appear to be new to science. Of these 15 species, 9 were also taken by Professor Bayley Balfour, F.R.S., during his visit to Socotra between February 11th and March 30th, 1880 [1]. The only one of Professor Balfour's captures not represented in the present collection is *Charaxes balfouri* Butl.

DANAINÆ.

LIMNAS CHRYSIPPUS Linn. (Nos. 1, 2.)

Two specimens; ♂ and ♀. These are paler than the average of African examples, bearing in this respect a greater resemblance t specimens from India. The white spots forming the subapical band are in both, but especially in the male, unusually small and discrete. Some African specimens show the same character, but rarely in so pronounced a form [2]. The Socotran male has most of the veins in the hind wing, especially the branches of the median, thickly covered with white scales, which also extend to narrow adjacent areas of the wing, and form a ring around the black patch marking the position of the submedian scent-gland. A trace of the same white colouring of veins and adjacent areas is also visible in the female. This is a first approximation to the condition seen in var. *alcippoides*, Moore, where, however, the veins themselves often retain their brown colour in the midst of the whitened area of the hind wing. It is noticeable that both the Socotran specimens are in fine condition, though the collection as a whole has suffered much from the attacks of beetle larvæ.

"Seen only in the hills, flying strongly. Not common."—*E. N. B.*

[1] See Proc. Zool. Soc. 1881, pp. 175–180, pl. xviii.

[2] A pair from Aden in Coll. Brit. Mus. closely resemble the Socotran examples in this respect, and also in the general ground-colour. A female specimen from Aden in Coll. Hope, of the same ground-colour, also shows an approach to the discrete condition of the subapical white spots. Prof. Balfour's Socotran specimen, a female, has like Mr. Bennett's pair a pale ground-colour, but the subapical spots are less discrete. It is curious that specimens of *L. chrysippus* in Coll. Brit. Mus. from Athens, Turkey, and Syria are as dark as the ordinary form from Africa.

ACRÆINÆ.

ACRÆA NEOBULE Doubl. (Nos. 10-15.)

Acræa neobule Doubl.; Butler, Proc. Zool. Soc. 1881, p. 177, pl. xviii. fig. 5.

Six specimens; probably all females, but in one the abdomen is missing. These resemble *A. neobule* from the African mainland, but the powdering of black scales at the apex of the fore wing is much more distinct, and there is little or no admixture of brown or reddish scales with the black of the apex, as generally occurs in *A. neobule*. In all six examples the ground-colour is deeper in tone, and the dark border of the hind wing is broader and has a smoother outline than in average specimens of *A. neobule*, while the pale spots in the dark border are on the upperside either not present or comparatively indistinct. All the black spots on the hind wing are relatively larger than in normal *A. neobule*; they are also more uniform in size; the two spots which occur one on each side of the discoidal vein, usually very small in *A. neobule*, are here less different in bulk from the other dark spots of the wing. The abdomen in these specimens is black with spots of the pale ground-colour, as in *A. horta* Linn. A female *A. neobule*, brought from Socotra by Prof. Bayley Balfour, has a perceptible powdering of reddish scales at the apex of the fore wing, but in other respects resembles Mr. Bennett's specimens. It was noted and figured in 1881 by Mr. Butler (*loc. cit.*), who, however, refrained from giving it a specific name in the absence of further examples. From the present series it seems probable that the differences from normal *A. neobule* are fairly constant, but not sufficiently so to warrant separation. It is worth remarking that in Reiche's figure of *A. neobule* from Abyssinia[1] the border of the hind wing is comparatively narrow, denticulate, and furnished with large light-coloured spots, while the apex of the fore wing appears to be powdered with red. The specimen represented differs therefore considerably from Mr. Bennett's series.

"Mostly seen in the hills, at an elevation of about 2000 feet. Not hard to get, the flight being slow and bold."—*E. N. B.*

SATYRINÆ.

CALYSISME ANYNANA Butl. (Nos. 3-7.)

Mycalesis anynana Butl. Ann. Nat. Hist. (5) iii. (1879), p. 187.
Calysisme socotrana Butl. Proc. Zool. Soc. 1881, p. 175, pl. xviii. fig. 7.

Five specimens; 3 ♂, 2 ♀. Two of the males and one of the females are much worn. The iris of the large ocellus on the underside of the fore wing, which is whitish in the male described

[1] Ferr. et Gall., 'Voy. en Abyss.' iii. p. 466, pl. 33. fig. 3. See Trimen, 'South Afr. Butt.' vol. i. 1887, p. 138.

by Butler (P. Z. S. 1881, p. 175), is in two of the present males, including the best preserved of the three, distinctly orange as in the female. The size of all the smaller ocelli on the under surface seems to vary in both sexes. The upper surface of the hind wing carries in the male the glandular patch and tuft of hairs which are characteristic of the genus (Moore, Lepid. Ceylon, 1880–81, p. 20). The under surface of the dorsal border of the fore wing, where it overlaps the hind wing, is similarly clothed in the male with pale and glistening scales, forming a pearly patch. Five specimens of *C. anynana* in Coll. Brit. Mus. from the Island of Johanna (Comoro Group) are apparently "wet-season" forms; but another specimen from the same locality and one from Zanzibar seem to be "dry-season" forms and are indistinguishable from Socotran examples.

"The commonest butterfly in the island, inhabiting plains and mountains alike. A ground-haunting species, apt to take cover. Never flying high, and always easy to catch."—*E. N. B.*

NYMPHALINÆ.

BYBLIA BOYDI, sp. n. (Nos. 16–22.) (Plate XXX. figs. 1 ♂, 2 ♀.)

Hypanis cora Feisth.; Butl. Proc. Zool. Soc. 1881, p. 177, pl. xviii. fig. 4.

Types (♂ and ♀) in Hope Museum, Oxford.

Seven specimens; 4 ♂, 3 ♀. Distinguishable from the "dry-season" form of *B. götzius* Herbst and *B. anvatara* Boisd. by the following particulars:—(1) The area of fulvous ground-colour lying between the black submarginal band and the oblique median black patch on the disc of the fore wing is in *B. boydi* divisible into two portions, separated by a pair of black denticulations which almost meet one another along the course of the first median branch. Of these two portions, *the posterior is conspicuously narrower than the anterior*, the narrowing being caused mainly by the encroachment outwards of the oblique median patch. The outline of this latter patch in the allied forms tends rather sharply inwards between the first median branch and the dorsal border, but in *B. boydi* it is continued to the dorsal border at such an angle as to preclude the fulvous area from expanding again posteriorly, as it does in normal *B. götzius.* (2) *A chain of small black spots* is more or less visible, crossing the fulvous median area of the hind-wing upperside. These spots, which correspond to a series constantly present in *B. ilithyia* Drury, are only rarely indicated in *B. götzius.* The above characters appear to be constant and distinctive. One or more of the following features may be found in specimens of *B. götzius* from various localities on the mainland, but they do not occur all together except in *B. boydi*, where the combination appears to be constant:—(1) The black costal bar of the fore wing is continued across the wing to meet the submarginal black band. (2) The fulvous submarginal spots of the hind-wing upperside are large,

subconical, and only slightly separated by the black-coloured veins. (3) All the black markings of the upperside are highly developed, especially the submarginal band of the hind wing, which encroaches considerably inwards. In the presence of the chain of small median dark spots and in the large size of the fulvous submarginal spots of the hind wing, *B. boydi* approaches *B. ilithyia*; in other respects it is much nearer *B. götzius*. The combination of characters above given renders the Socotran form easily recognizable among its allies, and seems to justify its separation as distinct. I have given it the name *boydi*, after the Principal of Hertford College, to whom Science in Oxford is under great obligations.

"Very common everywhere, hills and plains. Not conspicuously ground-haunting."—*E. N. B.*

Remarks on Geographical and Seasonal Forms in the Genus Byblia *Hübn.*—*Byblia götzius* Herbst (=*Hypanis acheloia* Wallengr.; =*H. ilithyia* var. A, Trimen, S. Afr. Butt. vol. i. 1887, p. 264) is probably entitled to distinct specific rank beside *B. ilithyia* Drury[1]. Each form, as pointed out by Trimen (*loc. cit.* p. 266) and by Barker (Trans. Ent. Soc. Lond. 1896, p. 415), has its own range of seasonal variation. This is also shown by good series of both the *ilithyia* and the *götzius* (or *acheloia*) forms in the British Museum and in the Hope Collection at Oxford. For a large proportion of these each collection is indebted to Mr. G. A. K. Marshall, whose specimens all bear such ample data with regard to locality, altitude, and exact time of capture, as to throw much light upon questions of local and seasonal modification.

The geographical distribution of the two forms is interesting. The *ilithyia* form, with some local variation in size and in the relative proportions of dark markings to fulvous ground-colour, is found in India, Ceylon, Arabia, and the greater part of Wallace's "East African" subregion, including the West African coast districts lying northwards from the River Gambia and southwards from the Congo. It also extends for some distance into the South African subregion, occurring commonly in the Transvaal and Natal highlands, and coming, though rarely, down to the sea at Durban. Its distribution is therefore mainly Indian and "East African" in Wallace's sense[2]. The *götzius* form, on the other hand, is absent from India and from a large portion of "East Africa." It is found at Sierra Leone, Cape Coast Castle, Lagos, Old Calabar, and the coast districts of the Gaboon and the Congo; but outside the limits of Wallace's West African subregion, *i. e.* in Senegal to the north and Angola to the south, it is replaced by typical *ilithyia*. Beginning again on the south-east coast, about the easternmost districts

[1] The evidence on which Mr. Marshall decides against their specific distinctness appears to me to require confirmation. See Marshall in Ann. Mag. Nat. Hist. 1896, xviii. p. 338.

[2] Wallace, 'Geographical Distribution of Animals,' 1876, vol. i. pp. 251, 258 and map.

of the Cape Colony[1], it becomes very common at Durban, and follows the coast-line northwards, occurring at the mouths of the Zambesi, in Mozambique, and at Wasin. Though it seems to be rarely if ever met with in the "South African" interior, it passes inland up the Zambesi and is found in Matabeleland and at Zomba on the Shiré; while the British Museum also contains specimens from Nyasaland, Lake Mwéru, Tanganyika, the Victoria and Albert Nyanza, Wadelai, the Galla country, Abyssinia, Somaliland, and Aden. Like *B. ilithyia*, it shows some amount of local variation which may perhaps justify the specific separation of certain geographical forms[2].

It appears therefore that, so far as is known, the distribution of the two species (or varietal groups) is fairly distinct, though their respective ranges coincide for a small portion of the South African subregion and to a larger extent in "East Africa," as at Wadelai, in Somaliland, and at Aden. It is further evident that while the distribution of the *ilithyia* form is continuous from India throughout the "East African" subregion, that of the *götzius* form is almost if not quite discontinuous, its area being separated into a western and an eastern division. In the light of these facts it is remarkable that the Socotran form is most closely akin, not to the *ilithyia*, but to the *götzius* type, nearly resembling in fact West African specimens of *B. götzius*, from which it is separated geographically by the whole width of Wallace's East African subregion. It is further of interest to note that the Madagascar and Comoro Islands form (*B. anvatara* Boisd.), though no doubt distinct, is also a modification, not of *B. ilithyia*, but of *B. götzius*[3]. *B. ilithyia*, being found at such distant points of the "East African" subregion as Senegal, Angola, and Somaliland, as well as in Arabia, India, and Ceylon, might well have been expected to be the form occurring in Socotra; and the fact that it is here replaced by a form of *B. götzius* suggests the possibility that this island, like the South African subregion, and Madagascar with the Mascarene group, contains relics of a more ancient African fauna that has been expelled or excluded from the bulk of the mainland by the great irruption of forms of life which is believed to have taken place from the north-east[4].

[1] It is implied by Mr. Marshall (*loc. cit.* p. 337) that this Southern race of *B. götzius* (to which he restricts Wallengren's name *acheloia*) occurs also in the Western districts of South Africa, where, he states, the Cunene River (north of Damaraland) appears to be its northern boundary.

[2] Mr. Marshall (*loc. cit.* pp. 337, 338) recognizes three local races—the Southern (*acheloia* Wallgr., of which *vulgaris* Butl. is the wet-season form), the Western and Central African (*götzius* Herbst), and the North-eastern (*castanea* Butl.). Prof. Bayley Balfour's Socotran examples of *B. boydi*, noted by Butler as *Hypanis cora* Feisth., are rather curiously ranked by Mr. Marshall under var. *acheloia* Wallgr.

[3] Trimen, South Afr. Butt. vol. i. 1887, p. 267.

[4] Wallace, 'Geographical Distribution,' 1876, vol. i. p. 218, &c. Prof. Bayley Balfour (Proc. Roy. Instit. vol. x. 1884, p. 296) discusses the affinities of Socotran with West and South African plants, and observes that "Sokotra indeed is, with Madagascar, to be regarded as the remains of a greatly advanced

The variations of the underside of the hind wing in both forms, *B. ilithyia* and *B. götzius*, have been well described by Trimen (*loc. cit.* pp. 265, 266). They are undoubtedly seasonal, as pointed out by Barker (Trans. Ent. Soc. Lond. 1895, p. 415), and by Marshall in the MS. notes and labels accompanying the series in the Hope Collection above referred to, as well as in the Annals & Mag. Nat. Hist. 1896, xviii. p. 333, &c. The deeply ferruginous hind wing, on which the three creamy bands stand out conspicuously, belongs in each case to the dry-season form, and there are several intermediate grades leading up to the dull ochreous yellow of the wet-season form. In addition to the points noted by Trimen, it may be remarked that in the wet-season form of *B. götzius* the black submarginal band of the hind wing is relatively broader, and the proximally adjacent strip of ochreous ground-colour narrower, than in the wet-season form of *B. ilithyia*. In the former, indeed, the band of ground-colour is often reduced to a mere chain of fulvous dots with dark edging, forming a proximal border to the dark submarginal band. The pairs of whitish internervular spots on the dark band are also much less regular and conspicuous than in *B. ilithyia*. In the dry-season forms the veins crossing the median creamy band are in *B. götzius* often traced out with the deep ferruginous tint of the ground-colour, which marking has the effect of dividing the median creamy band into spots; this is not seen in *B. ilithyia*. In *B. götzius* also the dark submarginal band seems never entirely to disappear, even in extreme dry-season forms, as it may do in *B. ilithyia*. It soon, however, loses the whitish internervular spots, which in the wet-season form are already less distinct than in *B. ilithyia*.

The Socotran *B. boydi* resembles most specimens of *B. götzius* from the West African subregion in having the dark costal bar of the fore wing continued rather heavily across the wing to join the submarginal band. This is also more or less the case with two females of *B. götzius* from Abyssinia and specimens of the same from Somaliland and Aden in the British Museum; but in examples from South and East Africa the connection between the costal and the submarginal dark bands is often slight or absent. On the other hand, in the submarginal series of spots of the fulvous ground-colour on the upperside of the hind wing, the Socotran form comes nearer to specimens of *B. götzius* from Somaliland, Aden, and the Galla country than to any I have seen from West

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African coast-line at a remote period." Messrs. Sclater and Hartlaub (Proc. Zool. Soc. 1881, p. 167) point out that *Drymœca hæsitata*, one of Prof. Balfour's Socotran birds described by them, is most closely allied to a form inhabiting Madagascar. Col. Godwin-Austen (Proc. Zool. Soc. 1881, p. 252) considers that the land-molluscan fauna of Socotra affords "strong evidence that the island was once directly connected with Madagascar to the south"; and adds that "it is not unreasonable to suppose that in Socotra, the Seychelles, Madagascar, and Rodriguez we have the remnants of a very ancient more advanced coast-line on this western side of the Indian Ocean."

Africa. The spots in question are in *B. boydi*, as in the British Museum specimens of *B. götzius* from the localities last named, larger, closer together, more conical, and less quadrate than in individuals from West or South Africa, though in dry-season forms from Natal and East Central Africa an approach is made to the Socotran condition. The dark submarginal band of the hind wing in *B. boydi* is broader than in most specimens of *B. götzius* from E. and S. Africa, whether "wet" or "dry" (the narrower band belonging generally to the "dry" form). It is much broader than in the specimens of *B. götzius* from Somaliland, Aden, and the Galla country above referred to, but not, perhaps, much broader on the average than in the female specimens from Abyssinia.

The present examples of *B. boydi*, like Prof. B. Balfour's pair, are all dry-season forms. In at least two of the seven (both males), as also in both Prof. Balfour's specimens, the whitish internervular spots on the dark submarginal band of the hind-wing underside have disappeared, and in one of these the patches of ground-colour immediately adjacent to the pale median band are obsolescent. The wet-season form of *B. boydi* is still unknown. To judge by the analogy of *B. götzius*, its upper surface must be still more heavily marked with black than that of the specimens collected by Prof. Balfour and Mr. Bennett.

Pyrameis cardui Linn. (Nos. 8, 9.)

2 ♀. This species was also observed by Prof. Balfour.

"Common everywhere. The three most abundant species, in order of frequency, were (1) *Calysisme anynana*, (2) *Byblia boydi*, (3) *Pyrameis cardui*."—*E. N. B.*

Junonia clelia Cram. (Nos. 23–28.)

Six specimens; 2 ♂, 4 ♀: two of the latter in a battered condition. These do not differ in any definite manner from specimens from the mainland and the Comoro Islands [1]. They are "dry-season" forms, the colouring of the hind-wing underside being fairly uniform and the ocelli obsolescent. This species was not obtained by Prof. Balfour.

"Very common in the mountains."—*E. N. B.*

Hypolimnas misippus Linn. (Nos. 29–32.)

4 ♀. These are of the ordinary form, showing no tendency towards var. *alcippoides* Butl. They have suffered much from the attacks of larvæ. Not obtained by Prof. Balfour.

"Fairly common; commoner than *L. chrysippus*. Chiefly in the hills. Flight strong."—*E. N. B.*

[1] In *J. epiclelia* Boisd., from Madagascar, the size of the creamy-white markings of the upperside is much reduced, but I doubt whether the other features mentioned by Trimen (*loc. cit.* p. 216) are constant points of difference from *J. clelia*.

Lycæninæ.

Tarucus theophrastus Fabr. (No. 33.)

1 ♂. This species has a wide range throughout the Indian and Ethiopian regions and the Mediterranean subregion of the Palæarctic. It does not occur in Prof. Balfour's collection.

Zizera lysimon Hübn. (Nos. 34–37.)

Lycæna lysimon, Trimen, South Afr. Butt. vol. ii. 1887, p. 45.

Four specimens; apparently 3 ♂ and 1 ♀. This species also was not obtained by Prof. Balfour.

"Found commonly everywhere, both hills and plains, but chiefly the former. Flight always close to the ground."—*E. N. B.*

A Lycænid collected by Riebeck, who visited Socotra soon after Prof. Balfour, was not determined[1].

Pierinæ.

Belenois anomala Butl. (No. 38.)

Synchloe anomala Butl. Proc. Zool. Soc. 1881, p. 178, pl. xviii. fig. 3.

One ♀. The specimen is broken, but less worn than the type, which is also a female. The large black spot at the end of the cell in the fore wing, subquadrate in the type, is here rather subtriangular, with the base directed inwards, and showing on both surfaces a slight proximal indentation. On the under surface the outer border of the fore wings is greyish shot with pink, not semitransparent as in the type.

Mr. Butler (*loc. cit.*) assigns this form to the genus *Synchloe*, but adds that "the possession of a male specimen would satisfactorily decide whether or not it is an unusually aberrant *Belenois*." The male is still unknown; the venation, however, is unmistakably that of *Belenois*, as the 1st subcostal branch in the fore wing is concurrent with the costal (cf. *B. mesentina*, *B. creona*, *B. gidica*, &c.), while the upper discocellular is straight and forms an open angle with the lower. There can be little doubt that this interesting species comes nearest to *B. abyssinica* Luc., the dry-season form[2] of *B. gidica* from the African mainland.

"Rare; only met with in the Haghier Range, at an altitude of about 2300 ft. In the same place another white butterfly of corresponding size was seen, with circular black spots [perhaps the male]. Both flew fast."—*E. N. B.*

Teracolus niveus Butl. (Nos. 39–42.)

Teracolus niveus Butl. loc. cit. p. 177, pl. xviii. fig. 1.

Teracolus candidus Butl. loc. cit. p. 179, pl. xviii. fig. 2.

One ♂, three ♀. The male and one female correspond with

[1] Taschenberg, Zeitschrift für Naturwiss. Bd. lvi. 1883, p. 182.

[2] See Barker, Trans. Ent. Soc. Lond. 1895, p. 419.

Butler's *T. niveus*; another female is more heavily marked; the third female agrees with his *T. candidus*. In the male a few yellow and orange scales form a minute speck proximally, adjacent to the black dot at the end of the cell on the underside of the hind wing. A similar yellowish speck occurs in the females, but tends towards the costal rather than the proximal aspect of the dot.

Dr. Butler now considers his *T. niveus* to be the wet-season and *T. candidus* the dry-season form of the same species. In reference to the faunistic affinity between Socotra and the Mascarene group (*supra*, p. 377), it is of interest to note that *T. aldabrensis* Holl., from Aldabra, appears to be the nearest relative of the Socotran *T. niveus*[1].

"The male was taken on Dec. 19th in the sandy coast-plain of Ghalansyah. It was rescued from the jaws of a lizard."—*E. N. B.*

Catopsilia florella Fabr. (Nos. 43–46.)

Catopsilia pyrene Swains.; Butl. Proc. Zool. Soc. 1881, p. 178.

Four specimens; 1 ♂, 3 ♀. The male and two of the females are much worn.

"Only seen in the plain of Tamarida. Flight strong."—*E. N. B.*

Papilioninæ.

Papilio bennetti, sp. n. (Nos. 47, 48.) (Plate XXX. fig. 3.)

Type in Hope Museum, Oxford.

Two specimens, both probably ♂, but the abdomen of one is imperfect. These resemble *P. demoleus* Linn., from the African mainland, but may be distinguished by the following characters:—(1) On the upper surface all the yellow markings are much reduced in size, and *the second spot from the dorsal border of the yellow median chain in the fore wing is more or less* **Z**-*shaped*, instead of being irregularly rhombic as in *P. demoleus*. (2) There is *a broad black area of almost uniform width* between the median and the submarginal chains of yellow spots on the fore wing. The corresponding area in *P. demoleus* is comparatively narrow, and conspicuously denticulated in consequence of the relatively large size of the median yellow spots. (3) On the under surface *the pale submarginal spots of the hind wing are quadrate*, or even elongated in a direction at right angles to the border of the wing; whereas in *P. demoleus* they tend to be oblong, with the long diameter parallel to the hind border. The same applies to the series of rudimentary eye-like marks immediately proximal to the yellow submarginal row. Another feature which is probably distinctive is the fact that in the eye-like mark within the cell on underside of the hind wing the blue edging with its accompanying buff crescent extends only along the posterior side of the triangular black patch, instead of being continued along two sides, the posterior and the dorsal, as in *P. demoleus*. An approach to

[1] See Butler, Ann. & Mag. Nat. Hist. 1897, xx. p. 464.

this condition may occasionally be seen in the latter species. Many specimens of *P. demoleus* from Aden resemble *P. bennetti* in the narrowness of the pale median band of the hind wing; they differ, however, in the other particulars.

Mr. Bennett's specimens were taken on the extreme summit of Jebel Dryet (4900 ft.), settled on a Bedaween's bright-coloured cotton wrap or loin-cloth. The species is a strong flyer. It was not often met with, and never at a less elevation than 3500 ft. It does not occur in the collection made by Prof. Bayley Balfour.

HESPERIIDÆ.

RHOPALOCAMPTA JUCUNDA Butl. (Nos. 49–51.)

Hesperia jucunda, Butl. Proc. Zool. Soc. 1881, p. 179, pl. xviii. fig. 8.

Three specimens, all ♂. This species, as remarked by Trimen (South Afr. Butt. vol. iii. p. 373) is near *R. keithloa* Wallgr. from the East African mainland. It is also allied to *R. taranis* Hew. (*R. anchises* Gerst.), which has a wide African distribution and occurs at Aden (Butler, *loc. cit.* p. 179).

"Found in the hills, and also in the coast-plain between Ghalansyah and Tamarida."—*E. N. B.*

GEGENES NOSTRADAMUS Fabr. (No. 52.)

One specimen, a ♀. This species, which extends throughout the Mediterranean subregion into the North-western districts of India, was not obtained by Prof. Balfour. Specimens from Aden (var. *karsana* Moore) are more sandy in colour than the Socotran example.

The Heterocera collected by Mr. Bennett consist of 26 specimens, belonging to 16 species. These have been kindly named by Sir George F. Hampson. There are no new forms among them; *Oligostigma incommoda*, which was described by Dr. Butler (Proc. Zool. Soc. 1881, p. 180) from a specimen obtained by Prof. Balfour, does not occur in Mr. Bennett's collection. The Socotran Heterocera, so far as they are known, appear to present a mixture of African and Oriental species, the former predominating, together with some widely-distributed types such as *D. pulchella*. As in the case of the Rhopalocera, the African element does not seem to be exclusively East African. It is unfortunate that the Moths collected by Riebeck[1] were never determined.

COSSIDÆ.

AZYGOPHLEPS INCLUSA Wlk. (No. 53.)

One specimen. Another packed by Mr. Bennett was completely destroyed by beetle larvæ.

"In the hills."—*E. N. B.*

[1] Taschenberg, Zeitschr. f. Naturwiss. Bd. lvi. 1883, p. 182.

Arctiidæ.

Deiopeia pulchella Linn. (Nos. 54–57.)

"Ardahan, &c. Always on the grassy slopes of hills. Lived in the grass; never flew more than 2 feet from the ground."—*E. N. B.*

Four specimens. This species was also obtained by Prof. Balfour.

Lithosia vetusta Wlk. (No. 58.)

One specimen.

Noctuidæ.

Agrotis divisa Wlk. (Nos. 59, 60.)

Two specimens, one much worn.

Euplexia conducta Wlk. (No. 61.)

One specimen.

Baniana intorta Swinh. (No. 62.)

One specimen.

Cerocala vermiculosa H.-S. (Nos. 63–69.)

Seven specimens.

Calpe emarginata Fabr. (No. 70.)

One specimen.

Geometridæ.

Hyperythra lucicolor Butl. (No. 71.)

One specimen.

Boarmia acaciaria Boisd. (No. 72.)

One specimen.

Craspedia derasata Wlk. (No. 73.)

One specimen.

Craspedia lactaria Wlk. (No. 74.)

One specimen.

Craspedia pulverosaria Wlk.? (No. 75.)

One specimen.

Pyralidæ.

Nephopteryx sp. (No. 76.)

One specimen, too much worn for recognition.

Metasia sp. (No. 77.)

One specimen.

Tortricidæ.

Teras sp. (No. 78.)

One specimen.

II. ORTHOPTERA.

By MALCOLM BURR, F.Z.S.

The Orthoptera collected in Socotra by Mr. Bennett are few in number, but not without interest. The new species of *Pœcilocerus* represents a genus found in Northern Africa and in the western part of Asia, and there is a new Cricket, of the genus *Landreva* Walker, with a similar, but wider, distribution. It is probable that these two species are peculiar to the island, as they are not migratory in habits, so far as is known, the Cricket at least being incapable of flight.

There is the usual percentage of cosmopolitan species, but the collection is hardly large enough to give a fair idea of the relation of the island to the neighbouring continents.

A Locustid has been described, *Pachysmopoda abbreviata*[1] (Tasch.), which is not found elsewhere, but was not taken by Mr. Bennett.

FORFICULARIA.

LABIDURA RIPARIA (Pall.).

One male (No. 79).

A cosmopolitan species; originally apparently an inhabitant of the Mediterranean subregion, also occurring in Java, Korea, South America (coll. m.), Burmah, and North America.

BLATTODEA.

PHYLLODROMIA sp.

A very fragmentary example (No. 80), which resembles, but is distinct from, the cosmopolitan *Ph. germanica* (L.).

ACRIDIODEA.

TRYXALIS NASUTA (L.).

One immature specimen (No. 81).

This species occurs in Southern Europe, throughout Africa, India, Burmah, and in Australia.

ACROTYLUS LONGIPES (Charp.).

The solitary example (No. 82) is a variety with the wings rosy at the base, the normal colour being yellow. A blue form has occurred at Zanzibar (*Brunner*). An inhabitant of South-eastern Europe, Asia Minor, Abyssinia, and Zanzibar.

PŒCILOCERUS SOKOTRANUS, sp. n. (Plate XXX. fig. 4.)

Statura minore. Caput conicum, pallidum, vertice inter antennas

[1] *Mecopoda abbreviata,* Taschenberg, Zeitschr. f. Naturwiss. Bd. lvi. 1883, p. 184.

minus producto, horizontale, supra atro, subtus in frontem percurrente, profundius sulcato, fronte reclinata, a latere visa vix sinuata ; antennæ breves, nigræ, apicem versus pallidiores, capite et pronoto unitis vix longiores; oculi prominuli. Pronotum cylindricum, fusco-testaceum, carinis nullis instructum, margine postico rotundato, sulco typico paullo pone medium sito ; lobi deflexi laterales marginibus, postico sinuato, inferiore recto, antico adscendente, angulis rotundatis. Elytra et alæ perfecte explicata, abdominis apicem vix attingentia, illa angusta, fusco-testacea, unicoloria, densissime reticulata, apice obtuse angulata ; hæ elytris breviores, badiæ, apicem versus pallidiores. Femora tibiæque antica et intermedia fusca, tarsi pallidiores ; femora postica extus pallida, media macula magna fusca ornata, intus testacea, fusco-reticulata ; genibus supra pallidis, lateribus atris ; tibiæ posticæ sordide testaceæ, spinis octo albidis, apice nigris, calcaribus terminalibus parvis binis utroque margine supra armatæ. Abdomen fuscum, cylindricum ; valvulæ ovipositoris longæ, sinuatæ, pubescentes. ♀.

Dimensions, ♀.

Long. corp.	30	millim.
,, elytrorum	17·5	,,
,, pronoti	7·5	,,

The two specimens (Nos. 87, 88) from which the d scription was drawn are somewhat discoloured by spirit, but that is not a very important injury. *P. sokotranus* is considerably smaller than the other species of the genus, and is probably peculiar to the island.

Two females (Nos. 83, 84). Upon the second segment of both specimens there is a curious round pale hard knob, so large that it has caused a space in the elytra where they cover it when at rest. I have omitted it from the description as it seems to be a foreign body, possibly a fungus.

There is also an immature Grasshopper (No. 85), possibly to be referred to the genus *Acridium*.

GRYLLODEA.

LANDREVA, sp. n. ?

A male Cricket (No. 86) of the genus *Landreva* Walk. seems to be new, but is not sufficiently good for description. It is small, testaceous, with truncate elytra and no wings. The tympanum is only visible on the exterior side of the anterior tibiæ (subgenus *Ectolandreva*, Sauss.); the posterior tibiæ are armed with five spines on each margin above, and four terminal spines.

III. INSECTS OF OTHER ORDERS. By several Contributors.

Five species of Odonata, two of Hymenoptera, and one of Diptera were also captured by Mr. Bennett: the first were kindly named by Mr. R. McLachlan, F.R.S., the second by Mr. W. F. Kirby, and the third by Mr. E. E. Austen.

The Odonata were all common species with wide distribution, and it is of interest that they should in this respect contrast so sharply with the Lepidoptera Rhopalocera and Araneidea, and to a less extent with the Orthoptera. The contrast is probably to be explained by the facilities for distribution which the Odonata possess in their powers of flight.

Mr. Bennett records that the Odonata are very numerous on the plains where streams abound.—E. B. POULTON.

Species of Odonata.

PANTALA FLAVESCENS Fabr. (No. 89.)

Mr. Bennett captured one specimen "on banks of streams passing Tamarida."

Mr. McLachlan describes the species as nearly cosmopolitan.

CROCOTHEMIS ERYTHRÆA Brullé. (No. 90.)

One specimen.

The species occurs in South Europe, all over Africa, Asia, &c. *R. M.*).

RHYOTHEMIS SEMIHYALINA Dujardin. (Nos. 91, 92.)

Two specimens. "Common near the lagoon at Ghalansyah."—*E. N. B.*

Widely distributed in Africa and occurs in Asia Minor (*R. M.*).

CERIAGRION GLABRUM Burm. (No. 93.)

One specimen.

Nearly all over Africa (*R. M.*). The British Museum contains examples from Socotra, Madagascar, Mauritus, as well as from the mainland of Africa.

Species of Hymenoptera.

BELENOGASTER SAUSSUREI Kirby.

Two specimens (Nos. 94, 95).

This species was described by Mr. W. F. Kirby (P. Z. S. 1881, p. 649) among the insects collected by Prof. Bayley Balfour in Socotra.

HARPACTOPUS sp. inc.

One specimen (No. 96).

A species allied to *H. crudelis*, Smith, but larger, and with reddish mandibles and tibiæ. The specimen is, however, in such bad

condition that a description would be useless if not misleading (*W. F. K.*).

Species of Diptera.

SARCOPHAGA, sp. inc.

One specimen (No. 97).

The condition renders it impossible to determine the species (*E. E. A.*).

IV. ARACHNIDA.

By the Rev. O. PICKARD-CAMBRIDGE, M.A., F.R.S., C.M.Z.S.

ARACHNIDA ARANEIDEA.

Fam. EPEIRIDÆ.

Subfam. NEPHILINÆ.

Gen. NEPHILA Leach.

NEPHILA BENNETTI, sp. n. (Plate XXXI. fig. 2.)

Female adult? (No. 98), length $8\frac{1}{2}$ lines.

This Spider is of the ordinary characteristic *Nephila* form, and at the hinder part of the caput are the two characteristic conical tuberculiform eminences, conspicuous in a transverse line; the colour of the caput is dark brown, with two large, somewhat oval, dull yellowish patches at the hinder extremity, each surrounding one of the conical eminences. The thorax is dull, pale yellowish, with black-brown lateral converging stripes, and the whole cephalothorax is thickly covered with light grey pubescence.

Eyes normal.

Legs long, moderately strong; 1, 4, 2, 3, furnished with hairs and slender spines. Femora yellow, slightly tinged with a smoky hue at the anterior extremity; genuæ of the first and second pairs dark brown, those of the third and fourth pairs yellowish; tibiæ, metatarsi, and tarsi deep brown, approaching black. The tibiæ of the fourth pair are furnished throughout their length with numerous coarse black hairs forming a brush; the femora of the first and second pairs have also a similar but not so strong a brush on their fore-half, the hairs on these last shorten in length gradually into the normal hairs of the remaining portion of the joint.

Palpi short, normal; humeral and cubital joints yellowish, radial and digital black-brown, the latter furnished with long coarse bristly hairs.

Falces powerful, normal in form, black-brown.

Maxillæ and *labium* black-brown, the latter with a central longitudinal reddish yellow-brown stripe.

Sternum triangular, slightly longer than broad; deep brown; with

marginal eminences opposite the basal joints of the legs; and the labium is yellowish.

Abdomen cylindrical; the hinder extremity somewhat produced and extending beyond the spinners. The fore extremity is dark brown, succeeded by a strong transverse pale-yellowish or cream-coloured band, the ends of which are produced backwards forming a lateral broken marginal stripe on each side. The upperside between these stripes is of a dull pale hue, closely reticulated with brown in a vermiform pattern, and along the middle is a series of four pairs of roundish pale spots covered with a shining satiny pubescence; the spots in each of these pairs are contiguous or nearly so, and they decrease in size from the foremost to the last pair, which are seated a little way from the posterior extremity of the abdomen. The sides are dark brown, marked with various subparallel undulating yellowish streaks, two largish dark-brown patches on each side being left untouched by them. The underside is deep brown, with a yellowish marginal line in front and on the sides; and beneath the produced portion is a longitudinal, central, silvery-white band stopping short of the spinners. The genital aperture is of great simplicity, consisting of a narrow transverse opening covered by a short, scarcely projecting lip.

This handsome Spider is allied to several other African species, such as *N. femoralis* Luc., *N. sumptuosa* Gerst., and *N. keyserlingii* Blackw., but appears to be abundantly distinct. The only example was not in first-rate condition.

Subfam. GASTERACANTHINÆ.

Gen. GASTERACANTHA Walck.

GASTERACANTHA SODALIS, sp. n. (Plate XXXI. fig. 3.)

Adult female (No. 99), length (not including the posterior abdominal spines) rather over $3\frac{1}{2}$ lines (nearly 8 mm.); breadth of abdomen (including the longest of the lateral spines) $6\frac{3}{4}$ lines (14 mm.).

This Spider is much like *G. madagascariensis* Vins., to which it is nearly allied, but the latter has the transverse abdominal black bars broken off in the middle, and the abdomen itself is wider in proportion from front to back than in the present species; the cephalothorax also and the abdominal markings and spines are of a deeper hue, in fact generally black, whereas in the present Spider they are red-brown. The posterior and fore-lateral spines also are longer and sharper pointed in *G. madagascariensis*, in which also the underside of the abdomen is less thickly blotched with yellow, and the sternum has a strong sub-triangular (or heart-shaped) central, clearly defined, pale yellow spot; while in the present Spider the abdominal blotching is reddish orange-yellow, and the sternum deep brown, with two small indistinct yellowish spots in a transverse line near the middle.

The *legs* are of a uniform deep brown colour, while in *G. madagascariensis* the coxæ and femora are of a brightish yellow-brown

(in some examples, however, of the latter the legs are of a more uniform dull yellow-brown).

Subfam. Tetragnathinæ.

Gen. Tetragnatha Walck.

Tetragnatha boydi, sp. n. (Plate XXXI. fig. 4.)

Adult female (No. 101), length 4 lines; length of cephalothorax 2 lines; length of falces $2\frac{1}{4}$ lines nearly.

Cephalothorax oblong-oval, truncated at each extremity, and widest near the middle; length double its breadth; lateral marginal impressions at caput very slight; caput and margins of thorax darker than the rest; yellow-brown, but in the dry specimen the colour is unreliable.

Eyes of posterior row equally separated; in a very slightly curved line, the convexity of the curve directed forwards; anterior row much more strongly curved, but with the same direction of the curve; central quadrangle slightly broader than long, and the fore side distinctly shorter than the hinder one; the fore-central pair of eyes longest, and seated on a strongish rounded tubercular prominence; each of the lateral eyes also on a tubercle. The eyes of each lateral pair are much nearer to each other than the fore-central pair are to the hind-centrals. Clypeus rather less in height than half the facial space.

Falces very long and projecting forwards, slightly longer than the cephalothorax; considerably divergent; slightly curved, rather constricted at the fore extremity. Fang more than three-fourths the length of the falx, strong, abruptly bent at the base where it is somewhat enlarged, and there is another somewhat shallow dentiform enlargement towards the middle on the inner side; and each of the falces is armed with a strong, somewhat curved, pointed tooth at its extremity, just below the outer side close to the insertion of the fang; also on the inner side nearly beneath the base of the fang is another strong sharp-pointed tooth; besides these teeth each falx has a double longitudinal row of others along the underside; those on the outside are most numerous (10 ?) and most equally separated, the inner ones (7 or 8 ?) strongest and more confined to the posterior portion of the falx, those of both rows diminishing in strength as they run backwards.

Legs very slender; 1, 2, 4, 3, very little difference between 2 and 4; furnished with hairs and a few short slender spines.

Maxillæ, *labium*, and *sternum* normal.

The *abdomen* was so shrivelled and devoid of colour that nothing can be said as to its colours or markings, which, however, are most probably distinctive of the species.

This Spider is nearly allied to *Tetragnatha taylori* Cambr. (South Africa), but the relative position of the eyes is different, as well as the form of the fang and the denticulation of the falces.

Fam. THOMISIDÆ.

Gen. SELENOPS Dufour.

SELENOPS DIVERSUS, sp. n. (Plate XXXI. fig. 1.)

Adult female (No. 100), length 10 lines.

General form and structure normal.

Cephalothorax considerably broader (at its hinder extremity) than long. Indentation at the junction of caput and thorax large and deep. Colour dark yellowish brown, marked with somewhat irregular pale markings and darker converging lines, and clothed with short grey and other hairs, and with a rather dense marginal row of short, curved, prominent spiniform bristles.

Eyes in normal position. The four centrals of the anterior row form a slightly curved line, the convexity of the curve directed forwards; the two central eyes are rather the smallest of the four, and are further from each other than each is from the lateral eye on its side.

Legs long, strong, furnished with spines and numerous hairs of varying length; a scopula beneath the tarsi, and below the two terminal claws a compact claw-tuft. The colour of the legs is black, marked and, rather irregularly, annulated with reddish yellow-brown; the annuli are clothed with coarsish grey hairs. The legs do not differ much in length, the second pair are the longest, and the first, apparently, slightly shortest.

Falces moderately strong, roundly prominent in front, straight, and of deep blackish red-brown colour.

Maxillæ rather short, oblong, rounded at the extremity, inclined towards the labium; colour dark yellow, pale yellowish at the ends, where they are furnished with fine white hairs.

Labium slightly longer than broad, oblong, rounded at the apex, which is yellowish, the rest deep brown.

Sternum rather longer than broad, short-oval, slightly truncated before, and notched at its hinder extremity. Colour pale dull yellowish brown.

Abdomen flattened, rather longer than broad, nearly quadrate, truncate before, the posterior corners well rounded. Upperside of a dull brownish hue, pretty thickly clothed with short greyish hairs, some of those on the sides disposed in minute groups or tufts giving it a spotty appearance; along the middle is a rather diffuse but symmetrical black pattern, formed by a central longitudinal stripe, emitting various spots and markings on each side, and ending in a transverse angulated, black, irregular bar near the hinder extremity: the surface of the abdomen from this bar to just above the spinners is distinctly paler than the rest; sides deep brownish, and underside like the upper in colour. Genital aperture small, but of distinctive form. Spinners short, of about equal length, compact, and similar in colour to the underside.

This Spider is allied to *S. dufourii* Vins., and also to *S. madagascariensis* Vins., but may be easily distinguished from the latter

by the pattern on the abdomen, of which the form also is different. In *S. dufourii* the pale posterior extremity shows on its posterior border five distinct pale points; the present species shows only three, and those somewhat irregularly defined. The present Spider is also of much larger size than either of those mentioned, the length given of *S. dufourii* being 12 millim., and that of *S. madagascariensis* 11 millim., whereas *Selenops diversus* measures in length 10 lines, or nearly as possible 21 millim.

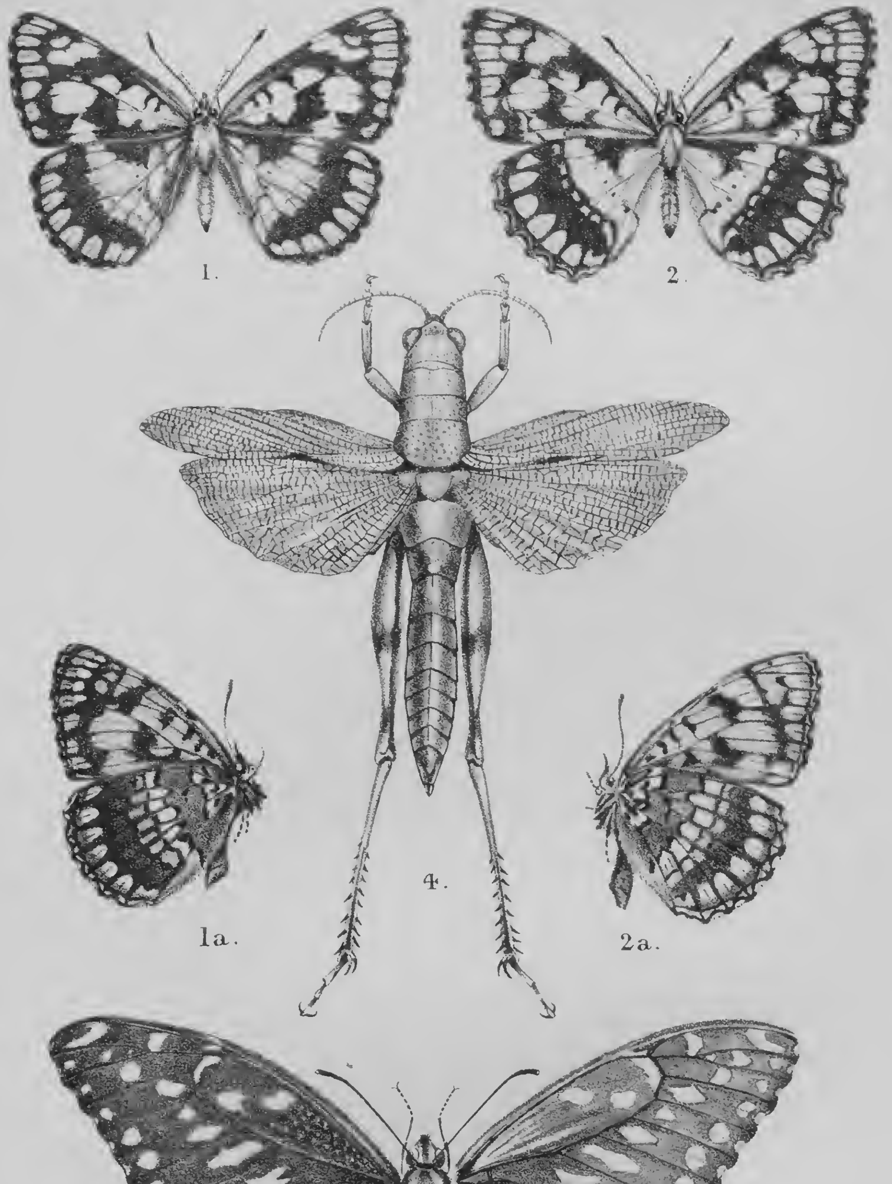
EXPLANATION OF THE PLATES.

Plate XXX.

Fig. 1. *Byblia boydi*, sp. n., ♂, p. 375.
1 *a*. ,, ,, ,, ♂, underside.
2. ,, ,, ,, ♀.
2 *a*. ,, ,, ,, ♀, underside.
3. *Papilio bennetti*, sp. n., ♂, p. 381.
4. *Pœcilocerus sokotranus*, sp. nov., ♂ p. 384.

Plate XXXI.

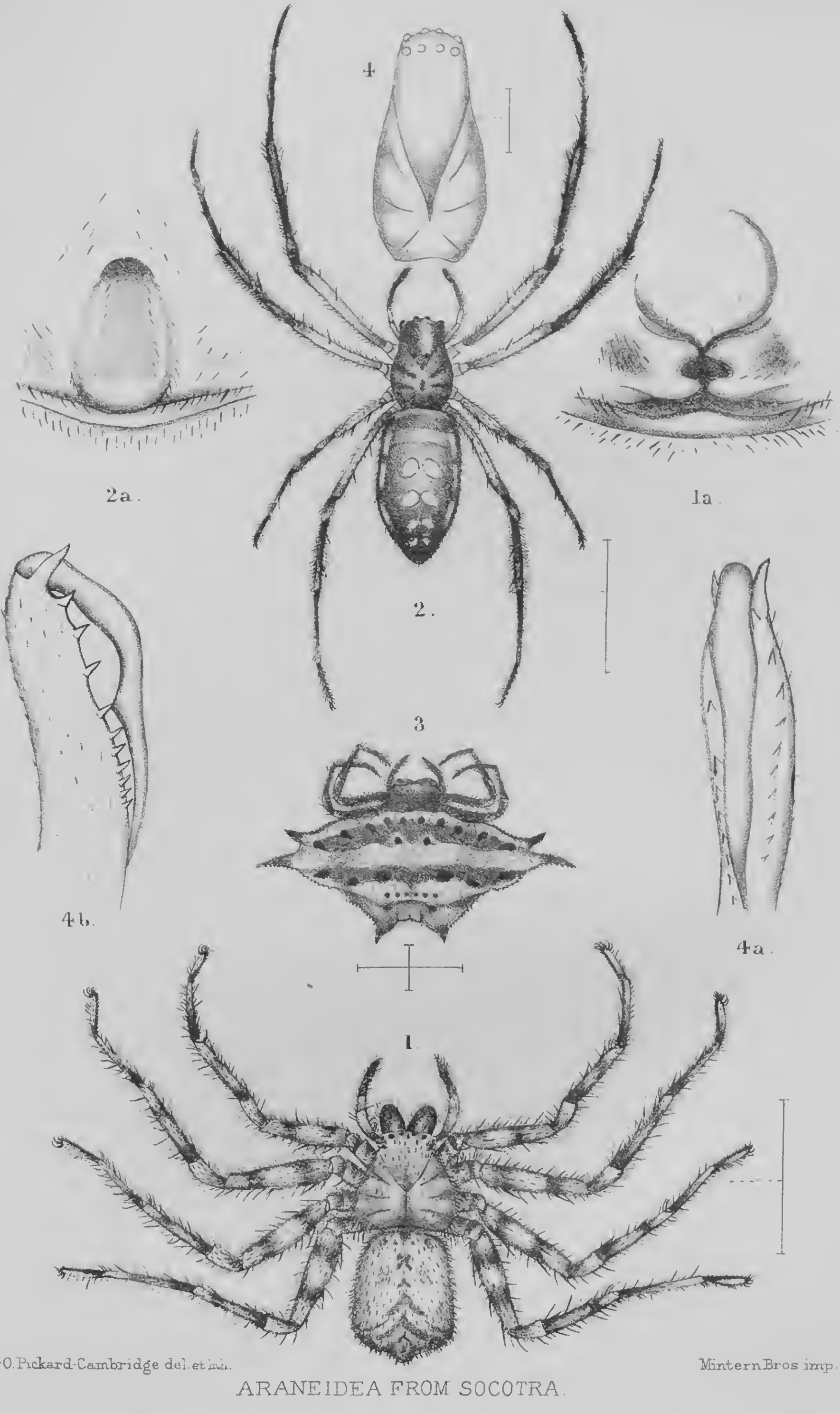
Fig. 1. *Selenops diversus*, sp. n., ♀, p. 390.
1 *a*. ,, ,, ,, Genital apertures.
2. *Nephila bennetti*, sp. n., ♀, p. 387.
2 *a*. ,, ,, ,, Genital apertures.
3. *Gasteracantha sodalis*, sp. n., ♀, p. 388.
4. *Tetragnatha boydi*, sp. n., p. 389. Cephalothorax and eyes.
4 *a* & 4 *b*. ,, ,, ,, Falx and fang in two positions.



Fredk O. Pickard Cambridge del. et lith.

Mintern Bros. imp.

INSECTS FROM SOCOTRA.



Fredᵏ O. Pickard-Cambridge del. et lith.

Mintern Bros imp.

ARANEIDEA FROM SOCOTRA.

ON A COLLECTION

OF

INSECTS AND ARACHNIDS

MADE IN 1895 & 1897,

BY

MR. C. V. A. PEEL, F.Z.S.,

IN

SOMALILAND,

WITH DESCRIPTIONS OF NEW SPECIES.

BY

C. V. A. PEEL, F.Z.S.,
E. E. AUSTEN,
F. A. DIXEY, M.A., M.D.,
HERBERT DRUCE, F.L.S., F.Z.S.,
C. J. GAHAN, M.A.,
GILBERT J. ARROW,
R. McLACHLAN, F.R.S.,
MALCOLM BURR, F.Z.S.,
AND
R. I. POCOCK.

[*From the* PROCEEDINGS OF THE ZOOLOGICAL SOCIETY OF LONDON,
January 23, 1900.]

On a Collection of Insects and Arachnids made in 1895 and 1897, by Mr. C. V. A. Peel, F.Z.S., in Somaliland, with Descriptions of new Species. By C. V. A. Peel, F.Z.S., E. E. Austen, F. A. Dixey, M.A., M.D., Herbert Druce, F.L.S., F.Z.S., C. J. Gahan, M.A., Gilbert J. Arrow, R. McLachlan, F.R.S., Malcolm Burr, F.Z.S., and R. I. Pocock.

(Plates I.–IV.)

Contents.

1. Narrative of the Expeditions.
By C. V. A. Peel, F.Z.S., F.R.G.S.

(First expedition to Somaliland. April 16 to August 7, 1895.)

Somaliland has always been known as the big-game hunter's paradise, and in consequence but few have had the energy to collect insects as well. Mr. E. Lort Phillips and Dr. Donaldson Smith, however, are notable exceptions. I always kept a killing-bottle in my tent and also collected outside whatever I happened to meet, but I must honestly confess that I never devoted my time seriously to collecting insects. Owing to the great sameness of thorn-bush and undergrowth, the Lepidoptera of Somaliland are disappointing. The Butterflies are few and somewhat uninteresting,

and the Moths are very local. The latter were nearly all collected on the banks of river-beds where there were trees, long grass, and undergrowth. The Beetles, on the other hand, simply swarmed, and there was also no lack of Orthoptera, Chilopoda, Diplopoda, Arachnida, &c.

On April 20th, 1895, I started from Berbera, the coast town of Somaliland, wending my way south-west along the maritime plain to Hargaisa. Insect-life was by no means plentiful in this hot parched-up desert country, but birds were numerous by the sides of the dried-up river-beds.

Hargaisa is a permanent Somali village on a gentle slope, overlooking a river-bed. There was luxuriant undergrowth and a few trees. Insect-life was consequently more plentiful, and I collected my first butterflies and moths here. Of the latter, the large species *Cyllogramma latona* Cr. and *Sphingomorpha chlorea* Cr. came to my lantern in great quantities at night. After leaving Hargaisa, I went south across the great waterless Haud District, through dense thorn-bush jungle. *En route* we suddenly emerged upon the Bun Saylah, a large open plain literally covered with game, notably Oryx, Hartebeest, Sœmmerring's Gazelle, and Ostriches. It took us a day to cross this, and then we entered dense jungle again. All this time I did but little insect-collecting, as, owing to the scarcity of water, I was always on the quick march. At Sassabanah we encountered water in deep wells and under the surface of a river-bed, the Webbi Jerrar. Here I collected some of the ticks described. Thence I marched to the Boorgha Country, and passed the everlasting red sand, entering a stony, hilly district. In this latter, Orthoptera were very numerous. I went as far as Mount Kuldush, marching along the Webbi Shebeyli, the great river of Somaliland.

The banks of this river were lined with trees and dense jungle, and butterflies and other insects were very abundant. Being unable to find a path for the camels down to the river-edge, and as I was running short of food, and many of my men had fever, I retraced my steps at the end of June. I followed the Sule River for a long way and reached Bun Jijjiga, a gigantic plain at the foot of the Harah Hills. Here I fell in with Abyssinians, who, however, behaved most cordially. Game was extremely abundant on this plain; but insects were somewhat scarce except at Whardi Datal, where there was long grass, in which Orthoptera simply swarmed. After leaving the plain I traversed thick jungle until reaching Hargaisa, where I rested to take up water before recrossing the great maritime plain called Guban (the hot country).

During this latter journey I came across a small herd of the Somali Wild Ass (*Equus somalicus*), and passed through a dense locust-cloud, which darkened the sun for hours and looked like a great fall of snow, the air being *white* with them. After a very exhausting march through this desert, where we encounted terrific dust-storms every day, we finally returned to Berbera and the coast.

(Second expedition. June 5th to October 29th, 1897.)

Being anxious to continue my researches in the Natural History of Somaliland, and if possible to cross the Ganana River and explore Lake Rudolph, I set out from Berbera again in 1897, accompanied by Mr. J. Benett-Stanford, F.Z.S., and his wife. We took with us a very large caravan of camels and escort. We crossed the great Gulis Range of mountains by the Gerato Pass, and encamping at Lehello, there awaited more camels, which were being bought for us in Berbera. Lehello lay in stony ground by the everlasting dried-up river-bed. Here insect-life was fairly abundant, as will be seen from a perusal of the subsequent parts of this memoir.

We removed next to the Toyo Plain, a vast open space devoid of trees, and then crossing the waterless Haud District reached the wells of Farfanyer in Ogaden. Here we were overtaken by a messenger from the political officer at the coast, forbidding us to go to the Ganana River, as the Somalis were reported to be fighting the Abyssinians there. This was a great disappointment to us, after getting together such a large caravan and escort. At Farfanyer we fell in with a great number of Somalis armed with rifles, which they had looted from the Abyssinians, whom they had defeated in two battles on the Webbi Shebeyli. At Farfanyer Mr. and Mrs. Stanford stayed, looking for rhinoceros, whilst I, with my separate caravan, went in search of a reported lion. Eventually I lost the Stanfords altogether, and although I sent guides to look for them, it was of no use, owing to the denseness of the bush. I had a very bad attack of fever, and after waiting for over a fortnight to try and get news of my friends, or to get a guide to take me back, I was obliged to give it up and march on alone.

Hearing of elephants in the Marehan and Haweea Countries, I determined to explore this little-known territory, and so marched across the great Marehan Desert and reached Habr Heshi, where we at length found water. Here I shot a fine lion which charged me, but I managed by great good luck to stop the animal when it was within a few yards.

After leaving Habr Heshi we encountered stony barren country, and pitched camp at Sinnadogho in the Haweea country, where there were fresh tracks of elephants. Here the natives were extremely troublesome, and I had a very anxious time. Several of my rifles, cloth for barter, and a pony were looted from me, and my followers were frequently attacked. I marched to Joh, the furthest point south-east I was destined to reach. We were then about six days' distance from the east coast. Finding no elephants, I went on to Kadea, looting on the way a pony in exchange for the one taken from me. Upwards of five hundred armed men made their appearance at this point, and I thought we were in for a big fight, some of the young men dancing themselves into a perfect frenzy. I was obliged to fire over their heads, to keep them from looting my camels. They succeeded, however, in stealing some

rifles, and I was obliged to take out my little army twice against villagers; but luckily no blood was shed, as the villagers, seeing the rifles coming, immediately restored my stolen property. I did no collecting to speak of here, as I was ill with fever and was having a very anxious time. I could get no guide to take me across the great waterless desert of the Marehan, and was obliged to load up the water-vessels at Doosa Moreb and start without one. I believe I was the first white man to visit the heart of the Marehan and Haweea Countries, and was right glad to shake off the dust from my feet on quitting those inhospitable tribes. How I lost my way crossing the Marehan Desert, ran short of water, and all but died of thirst, I have already described in the pages of the 'Wide World Magazine.' We reached Galadi in the Mijertain Country, and found water in the very nick of time, when I was almost at the last gasp. Here I became delirious, and knew nothing that was going on around me for hours. After leaving Galadi I became so ill and weak with fever that I did no further collecting, but was practically carried by my pony the whole way across the waterless Haud again to the Gulis Range, where I remained a few days to rest, and at length reached Berbera more dead than alive.

A full account of my two expeditions, together with a complete list of every mammal and bird known to inhabit the country, will be found in my book 'Somaliland,' published in 1899 by Messrs. F. E. Robinson & Co., London.

The specimens mentioned and described in the following pages are in the Hope Collection, University Museum, Oxford, with the exception of those which are expressly stated to be in the British Museum.

2. DIPTERA.

By E. E. Austen, Zoological Department, British Museum.

Mr. Peel's collection of Diptera was not extensive, amounting only to four specimens belonging to three species, one of which, however, is apparently new.

Fam. Tabanidæ.

Subfam. Pangoninæ.

Pangonia Latr.

Pangonia (*sens. strict.*) Rond.

Pangonia tricolor, sp. n. (Plate I. fig. 8.)

♀. Length 17 millim.; length of wing 15·5 millim.; length of proboscis 4 millim.

Shining black; first and second segments of abdomen (except a somewhat triangular area in the middle of the second segment, which, however, like the first and remainder of the second segment, is clothed with appressed silvery-white pile) white above; sixth and seventh segments and the narrow posterior margin of the fifth ochraceous, and

clothed with golden ochraceous pile; wings dark brown; alula, greater portion of the area behind the sixth longitudinal vein, and sometimes a narrow margin extending from the tip of the second vein to the apex of the anal cell, hyaline.

Head with an area surrounding the bases of the antennæ, extending from eye to eye, and including the lowest third of the front and an equal space below the antennæ, covered with white dust; *face* on each side below the antenna sparsely clothed with fine silvery hairs; *cheeks* dark brown; *occiput* covered with greyish dust, and base of head below thickly clothed with short white hairs; *antennæ* uniformly black, a distinct shoulder at the base of the third joint above. *Thorax* with a few short golden hairs in front of scutellum; pectus clothed with silvery-white pile, which extends on to the pleuræ above the front coxæ, and also in a stripe running up to the base of the wing, where the stripe ends in a fork; a narrow stripe of silvery-white pile extends from the base of the scutellum to the wing on each side. *Abdomen*: the white posterior margin of the second segment is narrowed in the middle above (thus leaving the black triangular area mentioned in the diagnosis), and continued on the ventral side as a narrow transverse band. *Legs*: *coxæ* greyish pollinose, and clothed with silvery-white pile; *tibiæ* with a slight reddish tinge. *Wings* with a fleck of silvery-white pile on the base of the first vein; *halteres* tawny.

Two specimens (both ♀). Type in British Museum; co-type in Hope Museum, Oxford. From Bun Feroli, north of Shebeyli River, West Somaliland; June 10–20, 1895: "biting men and animals."

In the present species the eyes are bare and the first posterior cell of the wing is closed; it is therefore a true *Pangonia* in Rondani's restricted sense.

Pangonia tricolor is closely allied to *P. bricchettii* Bezzi (Ann. Mus. Civ. Genov. xxxii. (1892), p. 181), also from Somaliland (Milmil). *P. tricolor* differs from *P. bricchettii* (which apparently is a somewhat smaller species) *inter alia* in only the first two, and not the first four [1], abdominal segments being marked with white, thus leaving between the white of the base and the ferruginous tip a broad shining black space, which is absent in Bezzi's species.

It may be noted that in the marking of the base of the abdomen of *Pangonia tricolor* there is a certain similarity to *Tabanus leucaspis*, v. d. Wulp (Notes Leyden Mus. vii. (1885), p. 74, pl. v. fig. 3), from the Gold Coast.

The collection of the British Museum contains two specimens of *Pangonia tricolor*, obtained by Capt. Swayne in Somaliland, from

[1] There is a discrepancy between Bezzi's diagnosis and his detailed description; in the former he writes (*op. cit.* p. 181) "*abdomine fasciis tribus transversis ex tomento albido ad marginem posticum segmentorum*," while in the latter he describes (p. 182) the *fourth* segment also as "a orlatura posteriore bianca," with the dorsum "Fornito di peli bianchi"; he describes the 5th, 6th, and 7th segments as "a peli ferruginosi."

nearly the same region as that in which Mr. Peel's specimens were found. Capt. Swayne also captured a single specimen of another species of *Pangonia* (too much damaged for determination), and three examples of a small Tabanid, somewhat resembling a *Hæmatopota* in form, but with clear wings; as the latter specimens are headless, it is impossible to determine them more precisely.

The following extract from a letter from Capt. Swayne, sent along with the flies to Dr. P. L. Sclater, is interesting as showing the apparent effect of the bites of these flies upon domestic animals. It is possible, however, that the real offender in these cases is either *Glossina longipennis*, Corti (the Somaliland Tsetse-fly), or else a species of *Stomoxys*, which abounds all over E. Africa. The latter species was found by Dr. J. W. Gregory to kill his camels on the Tana River, and was discovered by Capt. A. G. Haslam, A.V.D., to carry the *Trypanosoma* of Tsetse-fly disease. Since *Stomoxys* is a fly of small size, while *Glossina longipennis* is in shape not unlike a *Hæmatopota*, the true culprits may escape notice, the effects of their bites being attributed to the Tabanidæ. In the extract from Capt. Swayne's letter the *Pangonia* are called "Doog," and the small Tabanid "Balaad." Capt. Swayne writes as follows:—

"I send you three specimens of 'Doog' (a large fly) and three specimens of 'Balaad' (a small fly). . . . . . *I* was very much pestered by 'Doog' on my way through Ojaden to the Webbe Shabeyli in Somaliland. They swarmed on my camels, constantly drawing blood. The other fly, 'Balaad,' which looks not unlike the common house-fly, is far the worst fly on the Webbe; a valuable camel, on which I caught three or four, two months ago, is now dying, and the Somalis say that this is due to the bites of 'Balaad.' If there are many of them they kill horses and camels, and the Somalis will not have their live-stock grazing where 'Doog' and 'Balaad' are found."

Fam. ASILIDÆ.

Subfam. LAPHRINÆ.

LAMYRA Loew.

LAMYRA VORAX Loew.

Lamyra vorax, Loew, Öfvers. af K. Vet.-Akad. Förhandl. 1857, 355. 47; id. Dipt.-Fauna Südafrika's, 114 [1860].

A single ♀, West Somaliland, between April 16 and Aug. 7, 1895.

I refer Mr. Peel's specimen to this species with some hesitation. Its length is 15 German lines, instead of 11 or 12; the pollinose spots on the second and third abdominal segments are practically invisible; and there are differences in the length and coloration of the hair on the ventral surface of the abdomen. The specimen, however, is in poor condition, and even should it eventually prove to be long to a new species, it is too much damaged to be selected as a type.

Fam. MUSCIDÆ.

GLOSSINA Wied.

GLOSSINA LONGIPENNIS Corti.

Glossina longipennis, Corti, Ann. Mus. Civ. Genov. xxxv. (1895) p. 138.

A single ♀, West Somaliland, June 23–25, 1895.

Mr. Peel's note on this specimen says:—"Fly-belt sharply defined from Biermuddo to Boholo Deno."

This species, which is the Somaliland Tsetse-fly, was described from a male specimen obtained by Capt. Vittorio Bottego in June, 1893, on the Uelmal River, in the Boran Galla country. The British Museum possesses four examples from Somaliland (the exact locality not being known), collected and presented by Mr. Th. Greenfield.

Corti states (*loc. cit.* p. 139) that *G. longipennis* is "related to *G. tachinoides*, Westw., but differs in having the antennæ yellowish and not brown." It is, however, much more closely allied to *G. tabaniformis*, Westw., in which the length and size of the wings are even greater.

3. LEPIDOPTERA RHOPALOCERA.

By F. A. DIXEY, M.A., M.D., Fellow of Wadham College, Oxford.

DANAINÆ.

LIMNAS CHRYSIPPUS Linn.

Twenty-two specimens: 16 ♂, 6 ♀. It is remarkable that not one of these is of the type form, 14 ♂ and 6 ♀ being var. *klugii*, in which the black and white of the apical portion of the fore wing are wanting; while the remaining 2 ♂ are var. *dorippus*, which resembles var. *klugii* in every respect except that both surfaces of the hind wing are more or less suffused with white as in the *alcippoides* form of the type. The dates and places of capture were as follows: Hargaisa (North-west Somaliland), April 25–28, 1895, *klugii*, 4 ♂, 1 ♀, *dorippus*, 1 ♂; Arigumeret, Farfanyer District (Central Somaliland), June 20, 1897, in thick bush, *klugii*, 4 ♂, *dorippus*, 1 ♂; Haud, Odewein (North Central Somaliland), June 23, 1897, in dry river-bed with thickly wooded banks, *klugii*, 1 ♂, 1 ♀; Haud District, Eyk (North Central Somaliland), July 2, 1897, *klugii*, 1 ♂, 1 ♀; Habr Heshi, Marehan Country (East Central Somaliland), Aug. 26, 1897, in thick bush, *klugii*, 4 ♂, 3 ♀.

The ground-colour of the present specimens varies, the majority being of the usual light reddish amber seen in Oriental specimens of the type. Two or three of the *klugii* are of a pale dull fawn, and one or two approach the duller and darker ground-tint of the African *chrysippus*. These differences are not sexual, and there are transitional forms. The marginal white spots of the hind wing

are generally obsolete on the upper surface: they are, however. conspicuous in one of the two *dorippus*. Most of the male *klugii* show a slight powdering of white scales in the neighbourhood of the submedian scent-patch.

In describing the collections made fifteen years ago in Somaliland by Col. Yerbury and Messrs. Thrupp, Lort Phillips, and James (Proc. Zool. Soc. 1885, p. 756), Dr. Butler remarked of *L. klugii*: "This is clearly the prevalent *Limnas* in Somaliland; *L. chrysippus* and *L. alcippus* having, apparently, entirely disappeared, and *L. dorippus* being scarce." The fact that the only specimens of *L. chrysippus* obtained by Mr. Peel in his two distinct visits to Somaliland were of the *klugii* and *dorippus* varieties, confirms the above conclusion. It is also worthy of note that the collection made by Capt. Swayne in the Harar Highlands (Proc. Zool. Soc. 1898, p. 821) contained *L. klugii*, but no specimens of *L. chrysippus*, *L. alcippoides*, or *L. dorippus*.

Acræinæ.

Acræa neobule Doubl.

Four specimens: 2 ♂, 2 ♀. Caught at Gonsali (West Somaliland), June 24, 1895.

Acræa doubledayi Guér.

1 ♀. Gonsali, June 24, 1895.

Acræa serena Fabr.

3 ♀. Gonsali, June 24, 1895. In one of these specimens the subapical oblique dark bar on the fore wing is well marked, in the other two it is almost or altogether absent. One of the latter has the inner portion of the hind-marginal dark border of the fore wing almost obsolete, except near the apex.

Acræa mirabilis Butl. (Plate I. fig. 4.)

Acræa mirabilis, Butl. Proc. Zool. Soc. 1885, p. 760, pl. xlvii. fig. 1.

Seven specimens: apparently 5 ♂, 2 ♀. The British Museum possesses five specimens of this interesting *Acræa*, including the types. The present specimens differ from those in the National Collection (one of which retains a violet bloom) in the following particulars:—(1) The upper surface is generally of a warmer chestnut tinge. (2) The paler marks beneath, including the subapical patch of the fore wings, are rich yellow-ochre, instead of being nearly white as in the British Museum examples. In one of the latter, a female, the subapical patch on the upper surface also is creamy white. (3) In the present specimens there is a definite yellow band immediately external to the darker median band of the hind wing beneath. This is not the case in the British Museum examples, where the drab submarginal area gradually pales inwards towards the darker median band. In the ♀ type

this submarginal pale area is somewhat more distinct than in the other British Museum specimens, but it does not reach the condition seen in Mr. Peel's examples. The dated specimens in the National Collection were taken at Bundu Maria, Somaliland, in April. Mr. Peel's were all captured at Aoho, near Hodayu, Ogaden Country, Central Somaliland, on Aug. 20, 1897. The country consisted of stony hills, with thick bush. From the dates it seems probable that the present specimens belong to the wet-season, and the British Museum specimens to the dry-season form of the species.

NYMPHALINÆ.

JUNONIA CEBRENE Trim.

Six specimens, all males. Three were captured at Hargaisa, April 25–28, 1895; the other three in the summer of 1897, two bearing the date June 20, and the locality Arigumeret, Farfanyer District. These latter have the underside generally darker and more speckled than the spring examples; this is less apparent in the third specimen, from Central or East Somaliland, June 5–Oct. 29, 1897.

JUNONIA CLELIA Cram.

Six specimens: 3 ♂, 3 ♀. Hargaisa, April 25–28, 1895. The undersides of these specimens vary, but in all the ocelli are more distinct and the general tint is less uniform than in the ordinary "dry-season" form of the species.

JUNONIA TAVETA Rogenh.

One male. Hargaisa, April 25–28, 1895.

BYBLIA ILITHYIA Drury.

Four specimens: 3 ♂, 1 ♀. These are of the "intermediate" seasonal form, the female verging towards "wet"[1]. All are dated Hargaisa, April 25–28, 1895.

HYPOLIMNAS MISIPPUS Linn.

Twenty-eight specimens: 26 ♂, 2 ♀. It is very remarkable that of the only two female specimens obtained by Mr. Peel, one should be of the ordinary form, resembling the type of *L. chrysippus*, and the other of the var. *alcippoides*, differing from the former only in the whitish suffusion on both surfaces of the hind wing. From the facts given above (see under *L. chrysippus*, p. 10), it would appear that the form *klugii* of *L. chrysippus* occurs in Somaliland to the exclusion of the type, and it might have been expected that the form of *H. misippus* ♀ which so closely resembles *klugii*, viz. *H. inaria* Cram., would have been the form similarly

[1] For a discussion of geographical and seasonal forms in the genus *Byblia* Hübn., with especial reference to the relations between the forms occurring in Somaliland and Socotra, see Dixey, Proc. Zool. Soc. 1898, pp. 376–379.

prevalent in that region. So far as the evidence of Mr. Peel's collection goes, the reverse is the case. Another remarkable fact in the distribution of these parallel forms is that while *H. klugii* is extremely rare in India, the corresponding variety of *H. misippus* ♀ occurs there not infrequently [1]. It is also worthy of note that the white-winged West-African form, *Limnas alcippus* Cram., is accompanied by the ordinary, and not the white-winged, form of *H. misippus* ♀.

The dates and localities of the present examples are as follows:—Hargaisa, April 25–28, 1895, 6 ♂, 1 ♀ (ordinary type); Arigumeret, Farfanyer District, June 20, 1897, in thick bush, 2 ♂, 1 ♀ (var. *alcippoides* Butl.); Bally Maroli, Haud District (North Central Somaliland), June 25, 1897, in open plain, 14 ♂; Eyk, Haud District, July 2, 1897, 3 ♂. One other male was taken in Central or East Somaliland between June 5 and October 29, 1897, the exact locality being uncertain.

HAMANUMIDA DÆDALUS Fabr.

One male, Hargaisa, April 25–28, 1895. The underside is of the "dry-season" form, though not extreme.

LYCÆNINÆ.

POLYOMMATUS BÆTICUS Linn.

Two specimens, both males. On the thickly wooded banks of a dry river-bed, Haud, Odewein, June 21 & 23, 1897.

PLEBEIUS TROCHILUS Freyer.

Two females. Gerato Pass, Goolis Range (North-west Somaliland), June 9, 1897.

AZANUS JESOUS Guér.

Five males. Of these, four were captured on the dry sandy plateau of Edegan in the Haud District (North Central Somaliland), July 9, 1897; the remaining one was taken at Joh in the Haweea Country (East Central Somaliland), Sept. 20, 1897.

AZANUS THEBANA Stdgr.

Lycæna macalenga, Trim. S.-Afr. Butterfl. vol. ii. p. 74 (1887).

Three specimens: 1 ♂, 2 ♀. One pair from Odewein, Haud, June 21–23, 1897, dry river-bed with thickly wooded banks; the other female from the sandy plateau of Edegan, in the same district, July 9, 1897.

LYCÆNESTHES PRINCEPS Butl.

Two females apparently belonging to this form, though somewhat smaller than the type, which came from Abyssinia. Edegan, Haud District, July 9, 1897.

[1] See Swinhoe, Journ. Linn. Soc., Zool. vol. xxv. pp. 340, 341. For a summary of the facts at present known with regard to the distribution of the forms in question, see Poulton, 'Nature' July 6, 1899, p. 223.

SPINDASIS SOMALINA Butl.

Spindasis somalina, Butl. Proc. Zool. Soc. 1885, p. 764, pl. xlvii. fig. 5.

Two specimens, both males. Webbi Shebeyli, near Mount Kuldush (West Somaliland), June 28, 1895.

IOLAUS NURSEI Butl.

One male. Webbi Shebeyli, near Mount Kuldush, June 28, 1895.

PIERINÆ.

CATOPSILIA FLORELLA Fabr.

Forty-three specimens: 40 ♂, 3 ♀. Of these, 34 ♂ on July 2, 1897, and 1 ♀, July 4, 1897, were caught at a pool in the open plain of Eyk in the Haud District. The other captures were as follows:—Bun Feroli, N. of Shebeyli River (West Somaliland), June 10–20, 1895, 1 ♂; Odewein, Haud District (dry river-bed), June 21, 1897, 4 ♂, 2 ♀; Bally Maroli, Haud District (open plain), June 25, 1897, 1 ♂. The males, even those caught on the same day, vary much in size; in a few of the smaller examples the freckling of the underside is very faint or absent. The three females are all of the yellow form.

COLIAS MARNOANA Rogenh.

One female. Hargaisa, April 25–28, 1895.

TERIAS HAPALE Mab.

Two males. Hargaisa, April 25–28, 1895.

TERACOLUS EUPOMPE Klug.

Seven specimens; 4 ♂, 3 ♀. These were captured as follows:—a "dry season" ♂, and "intermediate" ♂ & ♀ at Hargaisa, April 25–28, 1895; a "wet season" ♂ in the dry river-bed at Odewein, Haud, June 23, 1897; a "wet season" ♂ & ♀ on the plateau of Edegan, July 9, 1897.

A remarkable form, apparently of the female of this species, was caught on the Sule River (West Somaliland), May 29, 1895. The wings have no marginal black except at the apex of the fore wing, and no black at the bases except a slight dusky powdering like that of the "dry season" male. The crimson apical patch has no chain of submarginal dark spots, but an ill-defined inner dark border to the patch is present, widened between the second and third median nervules. Beneath, there is only a very faint indication of the crimson apical patch, but the submarginal chain of dark spots in the fore wing is well-developed, except that there is no spot between the first and second branches of the median. The hind wings show a faint drab irroration, and the submarginal spots are ill-developed. The first submarginal spot of the fore wing, and the first two of the hind wing, together with the discoidal spot of the hind wing, are pale-centred, looking like incipient ocelli.

The "intermediate" female shows in some respects an approach to this condition, and the specimen just described may perhaps be considered as an extreme "dry season" form, though this would scarcely be expected in view of the recorded date.

TERACOLUS OMPHALE Godt.

Two specimens: ♂ & ♀. These were both caught at Hargaisa, April 25–28, 1895. They are of the "intermediate" form, and are smaller than the average size of the species.

TERACOLUS PHILLIPSI Butl.

Teracolus phillipsi, Butl. Proc. Zool. Soc. 1885, p. 772, pl. xlvii. fig. 11.

Nine specimens; 6 ♂, 3 ♀. The males are all of the "wet season" form; four were taken on July 4, 1897, at a pool in the open plain of Eyk, in the Haud District; the remaining two on the dry plain of Edegan in the same district, on July 9, 1897. Two "wet season" females were taken at Odewein, Haud, on June 21, 1897; and a "wet" or "intermediate" female at Hargaisa, April 25–28, 1895.

TERACOLUS HELVOLUS Butl.

Teracolus helvolus, Butl. Proc. Zool. Soc. 1888, p. 94.

Seven specimens; 5 ♂, 2 ♀. Four males and one female at Hargaisa, April 25–28, 1895. These are of the "dry season" form. A "wet season" ♂ & ♀ were taken in the river-bed at Odewein, June 23, 1897, and at the pool of Eyk on July 4, 1897, respectively.

TERACOLUS HELIOCAUSTUS Butl.

Teracolus heliocaustus, Butl. Proc. Zool. Soc. 1885, p. 768, pl. xlvii. figs. 8 & 9.

One male. Odewein, June 21, 1897.

TERACOLUS PROTOMEDIA Klug.

One male. Sibi (West Somaliland), May 27, 1895.

HERPÆNIA MELANARGE Butl.

Herpænia melanarge, Butl. Proc. Zool. Soc. 1885, p. 774.

Herpænia iterata, Butl. Proc. Zool. Soc. 1888, p. 96.

One male. Sibi (West Somaliland), May 27, 1895. A "wet season" form.

BELENOIS PEELI, sp. nov. (Plate I. figs. 5 ♂, 6 ♀.)

Types (♂ & ♀) in Hope Museum, Oxford.

Exp. al., ♂ 50 mm., ♀ 52 mm.

Male. Above white, with a pearly lustre at the base of the wings as in *B. gidica*, *B. abyssinica*, &c., best marked in the fore wing. Costa of the fore wing with a very thin edging of black. A black marginal spot at the termination of each of the following

veins:—in the fore wing the 2nd and 3rd subcostal, the two radial and the three median branches; in the hind wing the 2nd subcostal, the radial, and the three median. These marginal spots are oval in the hind wing, the long axis being parallel with the border of the wing; in the fore wing they are more or less triangular, with their bases at the margin. The first two at the apex of the fore wing are more or less fused; the remainder in both wings are distinct. There is a slight submarginal powdering of black scales in the fore wing between the 2nd and 3rd subcostal, and also between the two radials A much fainter powdering occurs between the 3rd subcostal and upper radial, and the slightest possible trace of a similar powdering between the 2nd and 3rd median. The marginal spots and the submarginal powdering mark out between them a very indistinct series of white subapical spots, the first three more or less wedge-shaped, the fourth nearly circular; these are barely to be separated from the general white surface. Beneath, the wings are white; there is a thin dusky line along the costa of the fore wing, and dark marginal spots, like those of the upper surface but smaller, occur at the extremities of the same veins in both wings. There is an orange-yellow patch at the base of the fore wing, occupying about one-fifth of the cell, and somewhat prolonged along the course of the subcostal vein. The same orange-yellow colour occurs in the hind wing as a streak along the costa, as a well-defined patch between the roots of the median and submedian veins, and as a median chain of spots crossing the disc of the wing from the costa to the inner border; these latter are seven in number, one occupying each interspace posterior to the costal vein except the space between the second subcostal and discoidal, and that between the second and third median. The third of the series surrounds the discocellular venule. This and the four succeeding spots are fairly distinct; the other two are faint. There is also a very slight indication of a submarginal series of dull yellow spots running parallel with the hind border of the wing.

Female. Above, like the male, but with the marginal dark spots somewhat larger. These are triangular in the hind wing, and in the fore wing become fused towards the apex into a narrow marginal band. The dark subapical powdering forms more definite and larger patches than in the male, and the white subapical spots are consequently more distinct. There is a trace of a marginal dark spot at the termination of the submedian vein of the fore wing, which is hardly if at all visible in the male. The basal pearly gloss is well marked, and the basal orange-yellow shows slightly through from the lower surface. Beneath, as in the male; but the basal orange-yellow occupies from one-third to one-half of the cell instead of only one-fifth. The submarginal series of spots is somewhat more distinct than in the male, and appears to be of the same orange-yellow as the median series.

In both sexes the first subcostal branch of the fore wing coalesces with the costal. The wings of the male are slightly more pointed,

as in *B. gidica*, &c., than those of the female. This species can readily be distinguished from any other of its genus by the entire absence of a dark discoidal spot from both surfaces of both wings in each sex, and by the presence of a double row of yellow or orange spots, unaccompanied by any dark markings, on the underside of the hind wing. It is probably a "dry-season" form, and perhaps most nearly recalls the dry-season *B. abyssinica* Luc., but it is far less heavily marked.

Two specimens; ♂ & ♀. Sule River, West Somaliland, May 29, 1895. Both, especially the female, somewhat worn.

Belenois mesentina Cram.

Nine specimens; 6 ♂, 3 ♀. Dates and localities as follows:—Sule River, May 29, 1895, 2 ♂; Odewein, Haud, June 21, 1897, 2 ♂, 1 ♀; pool at Eyk, Haud District, July 4, 1897, 2 ♂, 1 ♀; summer or autumn of 1897 (Central or East Somaliland), 1 ♀.

Nychitona medusa Cram.

1 ♀. Hargaisa, April 25–28, 1895. This is of the form *alcesta* Cram.

Mylothris agathina Cram.

1 ♀. Sibi, May 27, 1895.

Papilioninæ.

Papilio demoleus Linn.

Four specimens; 2 ♂, 2 ♀. Webbi Shebeyli, near Mt. Kuldush, June 27, 1895.

Hesperiidæ.

Sarangesa eliminata Moore.

Two females, one at the Webbi Shebeyli, June 28, 1895; the other at Odewein, Haud, June 21–23, 1897.

Rhopalocampta anchises Gerst.

4 ♂, 2 ♀. Two males and a female at Odewein, Haud, June 21–23, 1897; the remainder in the summer or autumn of 1897, in Central or East Somaliland, the exact locality being uncertain.

4. LEPIDOPTERA HETEROCERA.

By Herbert Druce, F.L.S., F.Z.S.

Mr. Peel's collection of Moths includes specimens of four new species.

Arctiadæ.

Secusio strigata Wlk.

North-west Somaliland, Hargaisa, April 25–28, 1895. One example.

Deiopeia pulchella Linn.

N. Central Somaliland, Odewein, in the Haud District, June 21–23, 1897. In dry river-bed with thickly wooded banks. Two specimens.

Noctuidæ.

Heliothis armigera Hübn.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Euplexia opposita Wlk.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Amyna selenampha Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens.

Amyna octo Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens.

Tarache caffraria Cram.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens. Somaliland, 1895 or 1897. One example.

Cosmophila sabulifera Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Eutelia subapicalis Wlk.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens. North-west Somaliland, Berbera, June 5–9, 1897. One example.

Pseudophia oppia, sp. n. (Plate I. fig. 1.)

Male. Head, antennæ, and collar white; thorax and tegulæ pale greyish brown; abdomen pale brown, each segment edged with white; the underside of the thorax, abdomen, and legs white. Primaries brown, the outer margin grey; a reddish-brown band edged with a metallic line crosses the wing about the middle from the costal to the inner margin; a short yellowish-white band at the end of the cell. Secondaries white, broadly bordered with black from the apex to the anal angle; the fringe black and white. Expanse 1 inch.

Hab. E. Somaliland: Joh, in the Haweea Country. Three specimens captured September 20, 1897. Type and co-type in the Hope Collection, co-type in the British Museum.

[16]

Pseudophia lineata, sp. n. (Plate I. fig. 7.)

Head, collar, thorax, and tegulæ pale greyish brown; abdomen wanting; antennæ whitish; legs and underside of the thorax white. Primaries greyish brown, palest at the base and on the costal and inner margin; a zigzag creamy-white line at the end of the cell extending to the base; a zigzag yellowish submarginal line extends from the costal margin near the apex to the anal angle; the marginal line bluish grey; the fringe dark brown. Secondaries greyish brown; the outer margin broadly bordered with dark brown; the fringe alternately brown and white. Expanse $1\frac{2}{5}$ inches.

Hab. North Central Somaliland: Haud, Odewein, June 21–23, 1897. In dry river-bed. One example. Type in Hope Collection, Oxford.

Cerocala munda, sp. n. (Plate I. fig. 3.)

The head, tegulæ, and thorax pale reddish brown; abdomen and legs reddish brown; antennæ and palpi brown. Primaries reddish grey, with a large reddish-brown spot near the base, one at the end of the cell and one on the inner margin close to the anal angle; the apex dark brown; a submarginal reddish line extends from the apex to the anal angle; the outer and inner margin greyish; the fringe white at the apex, the rest dark brown. Secondaries pale reddish brown; the outer margin spotted with black; a dark brown spot at the end of the cell; the fringe pale brown. Expanse $1\frac{1}{4}$ inches.

Hab. North Central Somaliland: Haud, Odewein, June 21–23, 1897. In dry river-bed. One example. Type in the Hope Collection, Oxford.

Gnamptonyx vilis Wlk.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One broken example.

Plecoptera reflexa Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens.

Trigonodes hypasia Cram.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Polydesma otiosa Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Cyllogramma latona Cram.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Eleven specimens.

Somaliland (1895 or 1897). Four specimens.

Ophiusa melicerte Cram.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens.

Somaliland (1895 or 1897). Four specimens.

Sphingomorpha chlorea Cram.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Somaliland (1895 or 1897). Four specimens.

Remigia repanda Fabr.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens.

Zethes hesperidoides Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Hypena abyssinialis Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Two specimens.

Hypena abyssinialis var. jussalis Wlk.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. Three specimens.

Sphingidæ.

Deilephila livornica Esp.

N. Central Somaliland, Haud District, Eyk, July 3, 1897. In the open plain, by thick bush. One ♀ example.

Phlegethontius convolvuli Schauf.

N. Central Somaliland, Eyk, in the Haud District, July 3, 1897. In the open plain, by thick bush. One ♀ example.

Geometridæ.

Tephrina disputaria Guen.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

Lasiocampidæ.

Chilena sabrina, sp. n. (Plate I. fig. 2.)

Male. Head and front of the thorax white; antennæ yellow; the collar and thorax pale brown; tegulæ pale brown edged with white; abdomen and legs white. Primaries pale brown, with two white bands extending from the base almost to the outer margin, the first line straight, the second curved; the costal margin edged with

white; the fringe white. Secondaries yellowish white. Expanse $1\frac{1}{4}$ inches.

Hab. West Somaliland (1895). One example. Type in Hope Collection, Oxford.

LIMACODIDÆ.

PARASA FULVICORPUS Hmpsn.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

ARBELA QUADRINOTATA Wlk.

N. Central Somaliland, Odewein, June 21–23, 1897. In dry river-bed. One example.

5. COLEOPTERA.

By C. J. GAHAN, M.A., and GILBERT J. ARROW.

With the exception of three species of *Curculionidæ* and two or three other species belonging to genera at persent undetermined, all the species of Coleoptera of which examples were collected by Mr. C. V. A. Peel in Somaliland are enumerated in the following list. Mr. Arrow has contributed that portion which deals with the Lamellicorn beetles and has assisted also in the determination of some of the species belonging to other groups. Mrs. M. K. Thomas has been good enough to determine the species of *Mylabris* and to describe one new form belonging to that genus. One or two species have been described from African specimens other than those collected by Mr. Peel. Fnll reference to the history of such specimens will be found in the descriptions. [C. J. GAHAN.]

CARABIDÆ.

CALOSOMA RUGOSUM De Geer.

Central or East Somaliland. One example. June 5 to Oct. 29, 1897. A widely distributed species, being found in South and East Africa, Abyssinia, Nubia, and in the island of Socotra.

ANTHIA FEROX Thoms.

N.W. Somaliland, Galadi in the Mijertain Country. One example, Oct. 4, 1897. Occurs also in Abyssinia.

POLYHIRMA CALLIAUDI Casteln., var.

N.W. Somaliland, Galadi, Oct. 4, 1897. One example. The sutnral vitta behind the scutellum is longer, and the elytra somewhat less strongly punctured than in normal examples from Abyssinia. Type of variety in British Musenm.

CHLÆNIUS sp.

Central or East Somaliland. One example (1897).

Hydrophilidæ.

Hydrophilus senegalensis Perch.

East Central Somaliland, Sinnadogha in the Haweea Country. One example, in water-tank, Sept. 8, 1897. This species is widely distributed throughout Africa.

Histeridæ.

Hister memnonius Erichs.

Central or East Somaliland. One example (1897). Occurs also in Senegambia, Nubia, Abyssinia, and East Africa.

Hister gehini Mars.

Central or East Somaliland. One example (1897). Found also in Senegambia, Abyssinia, and East Africa.

Saprinus semipunctatus Fabr.

Central or East Somaliland. Six specimens (1897). (One perhaps 1895 Expedition.)

Saprinus chalcites Ill.

Central or East Somaliland. Four specimens (1897). Occurs also in Egypt, Abyssinia, and East Africa.

Dermestidæ.

Dermestes vulpinus Fabr.

Central or East Somaliland. Ten specimens (1897).

Scarabæidæ.

Hybosorus illigeri Reiche.

Somaliland. Three specimens (1895 or 1897). This insect appears to be of almost world-wide distribution.

Phæochrous beccarii Har. Coleopt. Hefte, viii. p. 26.

Somaliland. Four specimens (1895 or 1897), apparently belonging to this species, which was described from N. Abyssinia.

Trox squalidus Oliv.

Somaliland (1895 or 1897). Two specimens were found of this insect, which is distributed generally throughout Africa.

Trox expansus Arrow, sp. n. (Plate I. fig. 16.)

Breviter ovatus, modice convexus, ferrugineo-tomentosus; capite bituberculato; prothoracis latitudine quam longitudine duplo majore, lateribus fortiter explanatis, serratis, angulis posticis fere rectis, disco quadri-carinato, carinis post medium convergentibus; elytrorum marginibus late explanatis, biseriatim tuberculiferis, dorso confluenter seriato-tuberculato, interstitiis

parce granulatis; antennis ferrugineis, articulo primo nigro, fusco-hirto; tibiis anticis acute quadridentatis, aliis serratis. Long. 21 *mm., lat.* 13 *mm.*

Type in British Museum.

The single specimen was obtained in Central or Eastern Somaliland (1897). This species is allied to *T. denticulatus* Oliv., which also occurs in Somaliland, but it is considerably larger and relatively broader, the widely dilated margins of the elytra making their outline almost circular. The elytral costæ consist of irregular tubercles which are separate at the base, more or less confluent on the disc, and small and scattered towards the apex; the alternate rows only of these reach the basal margins of the elytra. The anterior tibia is armed with four acute teeth placed at right angles to its axis and regularly increasing in size towards its extremity, the last being very sharp and prominent. *T. funestus* Lansb., a W. African species, appears to be nearly related to this insect, but is smaller and narrower, *T. expansus* being one of the largest at present known in the genus.

SCARABÆUS ISIDIS Cast.

North Central Somaliland, Bally Maroli in the Haud District. Two examples, June 25, 1897. This occurs throughout the Nile Valley and also in S.W. Asia.

SCARABÆUS BETTONI Waterh. Ann. & Mag. Nat. Hist. (6) xx. p. 553 (1897).

One specimen found July 26, 1895, at Whardi Datal, Northwest Somaliland. It was recently discovered by Mr. Betton in British East Africa.

GYMNOPLEURUS LÆVIS Arrow, sp. n.

G. splendenti *valde affinis, sed colore, et sculptura minus evidente, distinctus, fusco-niger, lævis, opacus; pedibus antennisque fusco-rufis, harum clavis ferrugineis; capite subtiliter granulato, antice acute quadridentato; prothorace convexo, subtiliter coriaceo, linea media lævi angusta, basi bi-impressa, lateribus parum grosse foveolatis, marginibus lateralibus anguste reflexis postice obtuse angulatis; elytris subtilissime disperse granulatis et vix striatis, absque plicatulis; pedum anteriorum tibiis serratis, dentibus tribus terminalibus acutis et longissimis munitis, femoribus emarginatis et dentatis. Long.* 16 *mm.*

Type in British Museum.

One example (1895 or 1897). This insect is almost black without a trace of metallic lustre. The surface is very smooth, with a fine granulation which is most apparent on the head and exceedingly minute on the elytra. The striation of the latter is almost obsolete and only visible under a lens. The three teeth upon the anterior tibiæ are very long and acute.

G. lugens of Fairm. is very near this species, but is more nearly related to *G. splendens* Cast., if not merely a variety of it.

COPRIS HARRISI Waterh. Ann. & Mag. Nat. Hist. (6) vii. p. 515 (1891).

Two female specimens of this insect, described from Abyssinia, were found at Whardi Datal (July 26, 1895).

ONTHOPHAGUS GERSTAECKERI Har.

A single specimen was brought from Central or East Somaliland (1897).

ONTHOPHAGUS GAZELLA Fabr.

One example (1895 or 1897). This insect occurs throughout Africa and even extends to Madagascar.

ONTHOPHAGUS sp.

A single female of another small species, probably new (1895 or 1897).

SCHIZONYCHA SQUAMOSA Raffray.

Three specimens (1895 or 1897). This species appears to be common in Somaliland, having occurred in several collections from that country.

SCHIZONYCHA NIGROFUSCA Arrow, sp. n.

Ovato-cylindrica, fere nigra, antennis pallidioribus, pectore flavo-hirto; clypeo æqualiter punctato, margine arcuato vix sinuato fortiter reflexo, fronte acute bicarinata, vertice spatioque post carinam anteriorem lævibus; prothorace antice et postice valde contracto, grosse et confluenter punctato, punctis squamiferis, lateribus crenatis et piliferis, ante marginem posteriorem utrinque elevato et lævigato; scutello fere lævi punctis nonnullis grossis sulcaque obsolete mediana; elytris cum pygidio dense sat grosse punctatis, punctis squamas setiformes vix perspicuas ferentibus; tibiis anticis tridentatis, dente superiore parvo. Long. 18–19 *mm.* ♀.

Type in British Museum, co-type in the Hope Coll., Oxford.

Two specimens, both females (1895 or 1897).

This insect is readily distinguishable from the majority of its congeners by its dark colour. It has some resemblance to the common W. African *S. crenata*, but the prothorax is relatively much smaller.

Single specimens of two other apparently new species were found (1895 or 1897), but in view of the large number of closely related forms described, it seems advisable to leave them for the present unnamed.

ANOMALA, sp. n.

Two specimens, ♂ and ♀, were collected (1895 or 1897), exhibiting a difference in the structure of the claws, and probably allied to *A. transvalensis* Arrow. As the anterior tarsi of the male

are imperfect, the affinity of the species cannot be decided with certainty, and it will therefore not be described.

There are two more single specimens (1897) of species of this genus, which can only be properly described from individuals of both sexes.

PHYLLOPERTHA HORTICOLA Linn.

One example (1897). The distribution of this insect is very remarkable. It is properly a northern insect, occurring throughout the North of Europe and Asia from the British Islands to Japan. In the British Museum, however, are specimens from South Africa, and Mr. Peel has now brought a specimen from Somaliland. It seems possible that these African examples have been artificially introduced.

HOMOTHYREA HELENÆ Schaum.

Two specimens (1897). This species has also been found in Abyssinia, in East Africa, and at Aden in South Arabia.

RHABDOTIS SOBRINA G. & P.

Fifteen specimens, found by Mr. Peel on mimosa bushes at Arigumeret, Farfanyer District of Central Somaliland.

BUPRESTIDÆ.

JULODIS LATICOLLIS Gahan, sp. n. (Plate I. fig. 15.)

Viridi-metallica, supra fere glabra, infra subaurata sat dense cano-pilosa; capite dense punctato; prothorace brevi, lato, supra valde convexo, dense minus fortiter punctato et subopaco, lateraliter rugoso-punctato, basi utrinque fortiter sinuato, medio acutangulatim producto; elytris quam prothorace vix latioribus, dense irregulariterque foveolatim impressis; foveolis subauratis, dense punctatis et plus minusve pubescentibus, interstitiis elevatis, angustis, reticulatis et impunctatis. Long. 18, *lat.* 8 *mm.*

Hab. Somaliland (1895 or 1897). One female example. Type in British Museum.

This species seems to be allied to *J. vittipennis* Fåhr., and *J. subvittata* Saund. (*Amblysterna*), but is readily distinguished from either by its broader form, its shorter, broader, and more convex prothorax, and its differently sculptured elytra.

STERASPIS sp.

Central or East Somaliland (1897). One example.

PSILOPTERA SOMALICA Gahan, sp. n. (Plate I. fig. 10.)

Purpureo-violacea, elytris (foveis pubescentibus propter 40 *cupreatis, prætermissis) nigris, tarsis supra viridibus; capite inter oculos sat lato, dense fortiterque punctato, versus medium sparse, ad latera dense sat longeque, pubescente; prothorace quam longiore sesqui-latiore, antice a medio angustato, supra sat dense forti-*

terque punctato, area parva triangulare ante scutellum lævi; elytris punctato-striatis, apice acuminatis, interstitiis antice fere planis, versus apicem angustis et convexis. Long. 25, *lat.* 9 *mm.*

Hab. Central or East Somaliland (1897). One example. Type in British Museum.

Head, prothorax, legs, and underside of a purplish-violet colour; tarsi metallic green above. Elytra black, each with about twenty shallow cupreous pits, which are densely punctured and more or less completely covered with greyish-white pubescence: six or seven of the smallest of these pits are placed at irregular intervals along the third elytral interstice, three of the larger pits on the fifth, three on the seventh, and about seven, diminishing in size from before backwards, along the ninth interstice; one of the larger pits on the fifth interstice, a little in front of the middle, and one at a short distance behind the middle, encroach upon the sixth interstice and nearly join two correspondingly large pits upon the seventh interstice.

This species differs from all other African species of the genus known to me in the disposition of the pubescent pits on the elytra, and is further distinguished by having each of the elytra narrowed to a single point, and not truncate at the apex.

Elateridæ.

Agrypnus longicornis Gahan, sp. n. (Plate I. fig. 11.)

Rufo-brunneus, luteo-pilosulus; antennis nigris, basin elytrorum paullo superantibus, articulo 3° *quam* 2° *haud longiore, articulis* 4° *ad* 10^{um} *angulatim sat valde productis; prothorace quam latiori vix longiori, supra sat valde convexo, lateribus medio paullo rotundatis, angulis posticis tenuibus, acutis, divaricatis; elytris tenuiter punctato-striatis. Long.* 17, *lat.* 5 *mm.*

Hab. Central or East Somaliland (1897). One example. Type in British Museum.

In general appearance this species resembles *A. bocandei* Cand., but is easily to be distinguished by the black colour and greater length of its antennæ. The third joint of the antennæ is a little broader, but not longer, than the second, and the joints from the fourth to the tenth are each produced antero-distally into a strong angulate process; the disc of the prothorax is more convex and somewhat less densely punctured, and the sides are more rounded in the middle than is the case with *A. bocandei.*

Dascillidæ.

Genecerus nebulosus Gahan, sp. n. (Plate I. fig. 9.)

Piceo-brunneus, cinereo- sat dense pubescens; elytris brunneo-nebulosis, longitudinaliter subcostatis; antennis (♂) *flabellatis vel* (♀) *serratis. Long.* 14–16, *lat.* 4–4½ *mm.*

Hab. Brit. E. Africa: Samburu, Voi and Ndi (*C. S. Betton*);

Central or East Somaliland (1897), two males (*C. V. A. Peel*). Type in the British Museum, co-type in Hope Coll.

Dark brown to reddish brown in colour; covered with an ashy-grey pubescence. Elytra with a number of dark-brown blotches, which are, however, absent in some specimens, so that the elytra have a nearly uniform grey colour. Head with a Y-shaped glabrous mark reaching from the antennary condyles to the occiput; eyes rather large, hemispherical, finely facetted. Prothorax about one half broader than long; its antero-lateral angles rounded and obtuse; the postero-lateral very slightly projecting and acute; the disc marked with a faint median impressed line extending from the anterior margin almost to the base. Elytra with some feebly raised and obtuse longitudinal costæ, along which the grey pubescence seems somewhat more dense than over the rest of the surface. Mesosternum with a small projecting process near the middle of its anterior margin, this process being fringed with fulvous hairs at its sides and apex. Posterior margin of the fifth abdominal sternite of the male bisinuate.

This species, though very distinct from *Genecerus cervinus* Walk., appears to be truly congeneric with it, agreeing as it does in all essential points of structure. The genus *Genecerus*, stated by Walker to be allied to *Plastocerus*, and by subsequent authors placed in the family *Cebrionidæ*, seems to me to belong to the family *Dascillidæ*, in which I should place it near *Anorus* Lec.

Lycidæ.

Lycus ampliatus Fåhr.

North-west Somaliland, Hargasia, April 25–28, 1895. One example. This species is found also in East Africa as well as in Natal and the Cape of Good Hope.

Cleridæ.

Necrobia rufipes De Geer.

Central or East Somaliland (1897). Three specimens.

Bostrychidæ.

Apate terebrans Pall.

West Somaliland, Bun Jijjiga, July 15, 1895. Three examples. This species occurs also in West Africa from the Gold Coast to Angola, in Natal, Nyasaland, and East Africa.

Bostrychus sp.

Central or East Somaliland (1897). Two specimens.

Tenebrionidæ.

Zophosis aromatum Gestro, Ann. Mus. Civ. Gen. (2) xv. p. 258.

Central or East Somaliland (1897). The two examples obtained by Mr. Peel are somewhat larger than the type from Archeisa

described by Dr. Gestro, but in other respects fully agree with the description.

Homala agona Fairm.

Central or East Somaliland (1897). Two specimens.

Rhytidonota delicatula Fairm.

Central or East Somaliland (1897). Two specimens.

Rhytidonota robusta Gahan, sp. n. (Plate I. fig. 13.)

Capite supra subtilissime punctato, clypeo utrinque leviter impresso; prothorace quam longitudine paullo latiori, lateribus marginatis antice arcuatim convergentibus, versus basin minus fortiter convergentibus, angulis posticis sat latis et retro paullo productis; elytris quam prothorace paullo latioribus, basi marginatis et ad humeros angulatis. Long. 19–20, *lat.* $7\frac{1}{2}$ *mm.*

Hab. Central or East Somaliland (1897), two specimens; and West Somaliland (1895), one specimen. Type (Central or East Somaliland) in British Museum, co-type in Hope Collection.

Prothorax nearly one-fourth broader than its length; widest across the middle, with sides converging strongly towards the apex, less strongly towards the base; basal margin straight in the middle, oblique towards each side and there forming with the lateral margin a subacute angle slightly projecting backwards. Elytra widest a little in front of the middle, narrowed slightly towards the base, and strongly towards the apex; completely margined at the base, and with a small projection at each of the humeral angles. Third joint of the antennæ twice as long as the second, and nearly equal in length to the fourth and fifth united.

Himatismus sp.

Central or East Somaliland (1897). One example.

Ocnera sp.

Somaliland (1895 or 1897). One mutilated specimen.

Pimelia hildebrandti Har.

P. cenchronota Fairm.

Central or East Somaliland (1897). Four specimens.

Psammodes sp.

Somaliland (1895 or 1897). Two specimens.

Amiantus sp.

Central or East Somaliland (1897). One mutilated specimen.

Amiantus sexcostatus Gahan, sp. n.

Niger; prothorace supra valde convexo, dense fortiterque punctato, lateribus paullo rotundatis, postice leviter marginatis; elytris ad suturam haud elevatis, utroque carinis tribus sat valde

elevatis instructo, carinis omnibus fere æquilongis, a basi ad declivitatem apicalem extensis; segmentis 2° 3°que abdominis in medio rufulo-pilosis. Long. 19, *lat.* (*ad med. elytrorum*) $10\frac{1}{2}$ *mm.*

Hab. Central or East Somaliland (1897). One example. Type in British Museum.

Black; prothorax strongly convex above, and strongly and rather thickly punctured; its sides slightly rounded in the middle and feebly marginate posteriorly, the margins becoming obsolete in front. Elytra depressed along the suture, each with three well-marked carinæ reaching from the base to the posterior declivous portion, the intervals between the carinæ being rather strongly concave; the concave sutural area between the innermost carinæ is sparsely granular in its anterior half. Femora rugosely punctured. Second and third abdominal segments with a patch of reddish pubescence in the middle.

SEPIDIOSTENUS ERINACEUS Fairm.

North Central Somaliland: Bally Maroli in the Haud District, June 25, 1897. Nine specimens, captured in the open plain.

SEPIDIUM MAGNUM Gahan, sp. n. (Plate I. fig. 12.)

Pube pallide cervina dense obtectum: prothorace utrinque plaga subnuda nigra, elytris rugis elevatis glabris nigro-fuscis, et plagis adspersis cretaceis; prothorace basi apiceque constricto, lateraliter carinato, carina antice obtusa, pone medium tuberculatim dilatata, disco in medio carinato, antice valde tuberculato, tuberculo crasso, apice rotundato supra sulcato-impresso haud bifurcato; elytris utrisque longitudinaliter bi-carinatis, transversim reticulatimque rugosis. Long. 29–35, *lat.* (*ad med. elytrorum*) 12–15 *mm.*

Hab. Central or East Somaliland (1897). Four examples. Type and co-type in British Museum, co-types in Hope Collection.

Brownish black, with the head, prothorax, underside, legs, and antennæ thickly covered with a pale fawn-coloured pubescence. Prothorax furnished with a large prominent tubercle, directed obliquely forwards from the anterior part of the disc; this tubercle is rounded at the extremity, impressed along the middle with a linear groove, and has on each side a naked and rugose black patch; from the base of the tubercle a median carina runs along the disc to the base of the prothorax. On each side of the prothorax there is a carina, obtuse in front, but more acute and prominent behind the middle, there forming a flattened tubercle, behind which the prothorax is abruptly constricted. Elytra each with two longitudinal and more or less sinuous carinæ, each of which gives off short transverse or reticulating ridges on both sides.

This species is one of the largest of the genus, being equal in size to *S. ruspolii* Fairm., from which it differs chiefly in having the lateral tubercles of the prothorax placed behind the middle

and in the presence of short transverse ridges running from the dorsal carina of each elytron towards the suture.

Sepidium bilobatum Gahan, sp. n. (Plate I. fig. 14.)

Pube rufulo-cervina dense obtectum: elytris supra plus minusve cinereis; prothorace antice valde tuberculato, tuberculo crasso antrorsum directo et bilobato; elytris dense fortiterque punctatis, utriusque disco tuberculato, tuberculis in seriebus duabus irregularibus ordinatis. Long. 17, *lat.* 6 *mm.*

Hab. Somaliland (1895 or 1897). One example. Type in British Museum.

Closely covered with a reddish-fawn-coloured pubescence, with the disc of each elytron ashy grey along the middle. Prothorax with a large tubercle directed almost horizontally forwards from the anterior part of the disc; this tubercle is distinctly bilobed in front, each lobe being rounded at the extremity; each side of the prothorax carinate, the carina dilated to form a tubercle just behind the middle. Elytra densely and strongly punctured; the disc of each with a number of sharply raised tubercles forming two irregular, longitudinal series.

Sepidium crassicaudatum Gestro.

Somaliland (1895 or 1897). Nine examples.

Vieta sp.

Central or East Somaliland (1897). One example.

Vietomorpha foveipennis Fairm.

Central or East Somaliland (1897). One example.

Micrantereus sp.

Central or East Somaliland (1897). One male example.

Micrantereus asidoides Fairm.

Central or East Somaliland (1897). One example.

Amarygmus sp.

Somaliland (1895 or 1897). One mutilated example.

Praogena nigra Gahan, sp. n.

Nigra; capite prothoraceque crebre punctatis et opacis; elytris nitidis, seriatim haud fortiter punctatis, interstitiis planis, sparse minutissime punctulatis. Long. 13, *lat.* $4\frac{1}{2}$ *mm.*

Hab. Somaliland (*T. Greenfield* and *C. V. A. Peel*, 1895 or 1897). Type in British Museum, co-type in Hope Collection.

Entirely black, with the elytra somewhat glossy and the rest of the surface more or less opaque. Head and prothorax closely punctured, the latter a little broader than long, slightly rounded at the sides. Elytra each with nine rows of rather small punctures, the first row (that next the suture) being very short;

intervals between the rows flat and sparsely and very minutely punctulate.

This species is larger and less convex than *P. gagatina* Mäkl., its prothorax is relatively a little broader, the rows of punctures on its elytra are much finer, and it is distinguished further from that species by its darker coloration and its glossy elytra.

Cantharidæ.

Mylabris hypolachna Gestro.

Central or East Somaliland (1897). Two examples.

Mylabris sennæ Gestro.

Central or East Somaliland (1897). Three examples

Mylabris lateplagiata Fairm.

Central or East Somaliland (1897). One example.

Mylabris somalica Thomas, sp. n.

Black, opaque, rugose, clothed with short yellow pubescence interspersed with longish black hairs. The head (which has an elevated shining median longitudinal line), prothorax, and elytra all thickly and coarsely punctured; the elytra dilated and widening towards the apex.

Each elytron ornamented with two long oval basal yellow markings, the marginal one joining a transverse yellow band extending to suture, and with a second transverse band, starting from but not quite touching the suture, extending down margin and curving round across the apex of elytron back to the suture: these markings are all margined by a fine brownish-red line. Antennæ red, with the exception of the first and second joints, which are black. The underside, legs, and tarsi are all black with long yellow hairs; the nails and spurs red.

This species is very similar to *Mylabris hypolachna* of Gestro[1] in size, form, and general characteristics, but it differs in having the second transverse band continued along the outer margin and thence across the apex to the suture.

Length 12 millim., breadth 4 millim.

Hab. Central or East Somaliland (1897). Type in the British Museum.

[M. K. Thomas.]

Epicauta amethystina Mäkl.

Somaliland (1895 or 1897). One example.

Cerambycidæ.

Macrotoma palmata Fabr.

West Somaliland: South-west Haud, Owari, East of Milmil (March 16, 1895). One example of this widely distributed African Prionid.

[1] Ann. Mus. Genov. (2) xv. p. 393 (1895.

Plocederus melancholicus Gahan, var.

Central or East Somaliland (1897). This variety occurs also in South Arabia and in British East Africa.

Plocederus peeli Gahan, Ann. & Mag. Nat. Hist. (7) ii. p. 42 (1898).

Somaliland (1895 or 1897). One example. Co-type in Hope Collection.

This species has been found in British East Africa as well as in Somaliland.

Pachydissus (Derolus) somalicus Gahan, sp. n.

Piceo-brunneus, griseo-pubescens; prothorace supra rugoso, lateraliter paullo rotundato, area opaca excisa inter notum pleurumque; elytris absque punctis (punctulis minutissimis pubescentiam gerentibus exceptis); femoribus subtus leviter bicarinatis; antennis (♀) quam corpore paullo brevioribus. Long. 17, *lat.* 4 *mm.*

Hab. Somaliland (1895 or 1897). One example. Type in British Museum.

Head and prothorax dark brown, with a greyish pubescence. Head with a sulcate impression on the vertex between the upper lobes of the eyes. Prothorax a little longer than broad; transversely wrinkled above; slightly rounded in the middle on each side, with a small excised space, bare of pubescence, just below the pronotum. Elytra parallel-sided throughout the greater part of their length, rounded at the apex; clothed with a short closely laid grey pubescence, and devoid of all punctures, excepting those very minute ones from which the hairs of the pubescence spring. Femora feebly carinate along each side near the ventral border. Prosternal process subvertical behind; the small antero-lateral processes of metasternum almost completely shutting off the epimera from the intermediate cotyloid cavities.

Phyllocnema semijanthina Fairm.

Central or East Somaliland (1897). Two examples.

Alphitopola peeli Gahan, sp. n.

Fusca; capite, prothorace, scutello et corporis inferioris lateribus pube fulvo-ferruginea obtectis; elytris fuscis, vitta suturali et vitta postica submarginali cinnamomeis, utroque elytro puncta basali et maculis quatuor—duabus (quarum interna elongato-ovali, medio fusco-punctata) ante medium, duabus (elongatis et postice conjunctis) pone medium—niveis ornato. Long. 17, *lat.* $5\frac{1}{2}$ *mm.*

Hab. Galadi in N.W. Somaliland. One example, Oct. 4, 1897. Type in British Museum.

Head and prothorax dark brown, covered with a short reddish-tawny pubescence. Prothorax transverse; with a small blunt tubercle at the middle of each side; with two transverse sulcate impressions near the base and two near the apex. Elytra dark brown, somewhat thickly punctured, with the punctures rather large near the base and diminishing in size posteriorly; a sutural

vitta, and a submarginal vitta on each elytron reaching from the middle to the apex, where it joins the sutural vitta, cinnamon-coloured; a small punctiform spot at the extreme base, two spots in front of the middle and two behind the middle of each elytron, snow-white; the inner spot of the anterior pair larger than the outer, elongate-oval in shape, and marked in the middle with a narrow brown spot; the outer spot of the same pair emarginate in front; the two spots of the posterior pair elongate, with the inner one commencing before the outer and coalescing with it behind. Body underneath with an ashy-grey pubescence along the middle, fulvous brown towards the sides; legs brown, more or less suffused with grey at the base and on the ventral side. Intercoxal process of the mesosternum very feebly tubercled in the middle. Last abdominal segment feebly and sinuately emarginate at the apex.

Antennæ longer (by the last three or four joints) than the body, third joint half as long again as the fourth.

Ceroplesis revoili Fairm.

West (April 16 to Aug. 7, 1895) and North-west Somaliland, Galadi (Oct. 4, 1897). Three examples, two from the latter locality.

Ceratites jaspideus Serv.

Somaliland (1895 or 1897). Ten specimens. This species occurs also in West and East Africa and in Abyssinia.

Calothyrza pauli (Fairm.).

Anoplostetha pauli Fairm. C. R. Soc. Ent. Belg. 1884, p. 124; Ann. Soc. Ent. Fr. 1887, p. 338.

West Somaliland, Bularli (May 24, 1895). One specimen.

In this species and in the closely allied South-African *A. jardinei* White the claws of the tarsi are divaricate, and the scape of the antennæ is entirely devoid of a cicatrix. Both species are out of place in *Anoplostetha* and should be referred to the genus *Calothyrza* Thoms., with which they agree in all essential points of structure. A third African species of *Calothyrza* has been described by Dr. Gestro (Ann. Mus. Civ. Gen. (2) xv. p. 423), the remaining species of this genus being the two Indian forms—*C. sehestedi* Fabr. Ent. Syst. Suppl. p. 146 (= *C. margaritifera* Thoms.) and *C. margaritifera* Westw.

Crossotus plumicornis Serv.

North-west Somaliland, Hargaisa (April 25 to 28, 1895). One example. This species is found in Senegambia, in East Africa and Natal, an example from the last-mentioned locality forming the type of White's *C. natalensis*.

Crossotus sp.

Central or East Somaliland (1897). One somewhat rubbed female specimen.

6. NEUROPTERA.

By Robert McLachlan, F.R.S. &c.

Planipennia.

Palpares papilionoides Klug, var.

West Somaliland, Sule River, May 29, 1895. One female.

It appears to me to be safer to regard this single specimen as a variety of *P. papilionoides* rather than to describe it as new. Klug's species was from Arabia Felix. When compared with Klug's description and figures, this female is somewhat larger and the dark bands of the anterior wings are more distinctly fenestrated in consequence of the dark colour being restricted to margining of the network. Some examples of *P. tristis* Hagen, diverge from the type form in the same manner, and I have a female from Somaliland that at first I thought was specifically identical with that from the Sule River, but there is a slightly different form of wing, and in *papilionoides* the abdomen has black longitudinal bands which are wanting in *tristis*.

Palpares walkeri McLachlan.

Sule River, May 24, 1895. One female.

The male of this species was described by me in the Ent. Monthly Mag. for August 1894 from two examples taken by Mr. J. J. Walker, R.N., F.L.S., at Aden, which are in my collection. Subsequently Col. Yerbury, R.A., F.Z.S., found examples of both sexes at the same place and presented them to the British Museum. Upon comparing the female from Somaliland with those from Aden, I see nothing that can be considered of specific difference. The female has never been described. It is larger (expanse about 130 mm.) and the wings are broader (19 mm.), the isolated black markings on the anterior wings are larger; on the posterior wings the fasciæ are both broader and longer, the second of them extending to the dorsal margin, and very broad and strongly angulate in the middle; the third is also very broad and connected more or less with a series of spots towards the dorsal margin. (In no two specimens do the dark bands and other markings precisely agree nor are they symmetrical on the opposing wings.)

Myrmeleon variegatus Klug.

West Somaliland (1895). One male, without indication of further locality. Described originally from Arabia Felix. I have what appears to be exactly the same species from the Sinai Peninsula. Probably widespread.

Odonata.

Cacergate leucosticta Burm.

East Central Somaliland: Haweea Country, Sinnadohga, by a water-tank, Sept. 8, 1897. One female.

A widespread African insect.

GYNACANTHA sp. ?

One immature female from the same locality as the preceding. This in all probability represents a new species, but I am not disposed to describe and name a species of this very critical genus from an immature female. It appears to be quite distinct from any West-African species.

7. ORTHOPTERA.

By MALCOLM BURR, F.Z.S., F.E.S.

(Except *Phasmatodea* by Dr. C. BRUNNER VON WATTENWYL.)

The collection of Orthoptera made by Mr. C. V. A. Peel in Somaliland is not large, but contains examples of a good number of genera and species new to science. These are distributed as follows:—

	Number of species.	New Genera.	New Species.
Blattodea..........	4	–	–
Mantodea	6	1	1
Phasmatodea	3	1	2
Acridiodea	15	1	2
Locustodea	11	1	7
Gryllodea	4	–	–
Total	43	4	12

It will be noticed that there are no less than seven novelties out of the eleven Locustodea captured, a high percentage, which is probably due to the stationary habits of these insects. Most of these new species are *Phaneropteridæ*, for there are only one Conocephalid and one Stenopelmatid, both of which are flightless forms.

The collection contains no Forficularia.

An account of a collection of Orthoptera made in Somaliland by the late Prince Ruspoli has been published by Herr Dr. Schultess Rechberg-Schindler. They are mostly of the same genera, but the species are different. This is especially noticeable among the new forms.

I take this opportunity of acknowledging my deep indebtedness to Herr Dr. C. Brunner von Wattenwyl, for his invaluable assistance in the identification of many of the more difficult and obscure species, especially for the determination and descriptions of the *Phasmatodea*, upon which group his knowledge is unrivalled.

BLATTODEA.

PHYLLODROMIIDÆ.

ISCHNOPTERA ATRA Walk.

Somaliland (April 16 to Aug. 7, 1895, or June 5 to Oct. 29, 1897). One male.

PERISPHÆRIDÆ.

DEROCALYMMA BOTTEGIANA Sauss.

Central or East Somaliland (1897). Two female specimens.

I cannot distinguish *D. analis* Sauss. from *D. bottegiana* Sauss. The former is merely referred to and included in the synoptical table, which is very difficult to follow. Mr. Peel's two examples appear to agree entirely with the description of *D. bottegiana* Sauss., which is described from Somali specimens. One of these specimens still retains the yellowish velvet coat which is so easily lost in handling. They are both a shade smaller than de Saussure's types.

PERIPLANETIDÆ.

BLATTA ORIENTALIS L.

Somaliland (1895 or 1897). One female.

PERIPLANETA AMERICANA (L.).

Somaliland (1895 or 1897). One female.

MANTODEA.

ORTHODERIDÆ.

CHARIEIS, gen. nov.

Oculi conici, apice pedunculati. Caput haud valde depressum. Colore griseo. Ocelli in triangulum positi; antennæ elongatæ, graciles, testaceæ; occiput convexum. Pronotum breve, sulculo irregulari transverso instructum, margine antico subsinuato, dilatato, margine postico rotundato, postice angustatum. Elytra et alæ perfecte explicatæ. Illa membranacea, remote venosa, hyalina, venis infuscatis, venulis transversis ramorum venæ radialis incrassatis, bicoloribus; membrana analis brevis, sed longior quam latior. Hæ hyalinæ, venulis areæ anticæ infuscatis. Pedes graciles; femora antica gracilia, spinis discoidalibus 3 parvis armata, spinis marginis externo irregularibus, primo minimo, 2° longiori, 3°–6um parvis, dehinc margine crenulato. Tibiæ anticæ spinis brevibus armatæ. Lamina subgenitalis ♀ magna, fornicata, rotundata. Cerci ♀ sat longi, laminam subgenitalem haud superantes. Lamina supraanalis ♀ brevis, transversa. ♀. ♂ ignotus.

This genus is a link between Brunner's two sections of the *Orthoderidæ*. In the form of the pronotum it agrees with *Chætessa* Burm., while the presence of small discoidal spines on the anterior femora would place it in the second division. The conical and pedunculated eyes, the spines of the anterior tibiæ, the discoidal spines, the somewhat long anal membrane of the elytra separate it from *Chætessa* Burm.; the form of the pronotum satisfactorily divides it from the *Eremiaphilæ*, *Humbertiellæ*, and *Chiropachæ*.

In general appearance and coloration it resembles *Chiropacha* and *Tarachodes*, but it differs in the depressed head.

CHARIEIS PEELI, sp. n. (Plate II. fig. 4.)

Parva, grisea. Elytra hyalina, venulis infuscatis. Alæ hyalinæ, venulis partis anticæ infuscatis. Pronotum inerme. ♀.

	♀.
Long. corporis	24 mm.
,, pronoti	3·5
,, elytrorum	22
Lat. max. pronoti	3
,, min. ,, ...	2
Long. fem. anticorum	3·5
,, tibiarum ,, ...	2·5

Patria. West Somaliland: North-west Haud, Abriordi Garodi, May 4, 1895. One female example. Type in Hope Collection, Oxford.

(In the figure, the antennæ and apex of the abdomen are wanting.)

CHIROPACHA DIVES Sauss.

West Somaliland: North-west Haud, Abriordi Garodi, May 4, 1895. Three male specimens.

CHIROPACHA GILVA Charp.

West Somaliland: North-west Haud, Abriordi Garodi, May 4, 1895. Two specimens, male and female.

MANTIDÆ.

POPA UNDULATA (Fabr.).

West Somaliland: North-west Haud, Abriordi Garodi, May 4, 1895. Two specimens, one male and one nymph.

MIOMANTIS FENESTRATA (Fabr.).

West Somaliland: North-west Haud, Abriordi Garodi, May 4, 1895. One male.

HIERODULA sp.

North-west Somaliland, Berbera, April 16, 1895. One mutilated specimen.

PHASMATODEA.

By C. BRUNNER VON WATTENWYL.

CLITUMNIDÆ.

BURRIA, gen. nov.[1]

♀. *Caput elongatum. Antennæ tertiam partem femorum anticorum haud attingentes, articulo secundo moniliformi. Thorax granulosus. Femora omnia acute carinata, mutica. Segmentum abdominale octavum longum, segmenta bina terminalia unita superans. Segmentum anale parum compressum, minime emar-*

[1] In honorem scrutatoris assidui Malcolm Burr.

ginatum, lamina supraanali minima apposita. Cerci breves, recti, teretes. Operculum longissimum, segmenta abdominalia tria terminalia triplo superans, compressum, acuminatum.

Dispositio specierum.

1. Mesonotum et metanotum irregulariter granulosa. Statura major .... *longixipha*, sp. n.
1'. Mesonotum in margine laterali dense granulosum, medio granulis raris obsitum. Metanotum læve. Statura minor .... *farinosa*, sp. n.

1. Burria longixipha, sp. n. (Plate II. fig. 6.)

♀. *Mesonotum et metanotum irregulariter granulosa.*

	♀.
Long. corporis (operculo excluso)	104 mm.
„ mesonoti	20
„ metanoti cum segmento mediano..	15
„ segmenti mediani	3
„ femorum anticorum	25
„ „ intermed.	21
„ „ posticorum	24
„ operculi	32

Patria. West Somaliland (1895). One female. Type in Hope Collection, Oxford.

2. Burria farinosa, sp. n.

♀. *Caput totum farinosum. Thorax vitta mediana longa farinosa ornatus, necnon apex abdominis farinosus. Mesonotum marginibus dense granulosis, medio in vitta farinosa raro granulosum.*

	♀.
Long. corporis (operculo excluso)	68 mm.
„ mesonoti	12
„ metanoti cum segmento mediano..	11
„ segmenti mediani	2
„ femorum anticorum	19·5
„ „ intermed.	14·5
„ „ posticorum	18
„ operculi	26

Patria. West Somaliland, Bun Jijjiga (July 15, 1895). One female. Type in Hope Collection, Oxford.

Leptynia sp.

West Somaliland, Bun Jijjiga (July 15, 1895). Five mutilated specimens.

Acridiodea.

Truxalidæ.

Truxalis nasuta (L.).

North-west Somaliland, Whardi Datal, July 26, 1895. Three females.

TRUXALIS UNGUICULATA Ramb.

North-west Somaliland, Whardi Datal, July 26, 1895. Seven females, one male.

MACHÆRIDIA BILINEATA Stål.

North-west Somaliland, Whardi Datal, July 26, 1895. I refer a mutilated larva to this species.

EPACROMIA THALASSINA (Fabr.).

West Somaliland (1895). One example.

ŒDIPODIDÆ.

HUMBERTIELLA TENUICORNIS (Schaum).

West Somaliland : Boholo Deno, near R. Shebeyli, June 24, 1895; three male specimens, one female. Somaliland (1895 or 1897); one male and one female.

This species is purely a native of tropical Africa.

GASTRIMARGUS VERTICALIS Sauss.

West Somaliland (1895). One male and one female specimen.

Var., *fusca, fascia fusca alarum vix perspicua.*

North-west Somaliland, Hargaisa, April 25–28, 1895. One female specimen.

ŒDALEUS INSTILLATUS, sp. n.

Pronotum haud valde elongatum, fusco-testaceum, indistincte fusco-notatum. Tempora acuta, trigonalia. Statura minore. Gracilior. Frons subreclinata; costa frontalis latior, marginibus a vertice subdivergentibus; vertex ad frontem haud rotundatus. Pronoti crista humilis, acuta, sinuata, margine postico acutangulo. Elytra venis spuriis completis, area ulnari irregulariter reticulata, fusco-testacea, dimidia basali fasciis 3 latis fuscis, 2 latis pallidis, opacis, dimidia apicali plus minus hyalina, maculis nebulosis infuscatis ornata. Alæ basi flavicantes, fascia fusca lata semilunari, marginem posticum attingenti ornatæ, ultra hanc hyalinæ, apice macula fusca, 2 lobos includenti ornata. Pronotum metazona quam prozona haud brevior. Femora postica testacea, extus punctulata, vel irregulariter fasciata. Tibiæ posticæ rufescentes. ♂ ♀.

	♂.	♀.
Long. corporis	20 mm.	29 mm.
,, pronoti	5	6
,, elytrorum	22	26·5
,, femorum posticorum	..	15

Patria. West Somaliland (1895). Two specimens. Types, male and female, in Hope Collection, Oxford.

This new species falls into the second division of de Saussure's subgenus *Œdaleus sensu stricto.* It is a great deal smaller than

Œ. nigrofasciatus de G., and *Œ. infernalis* Sauss., and falls between *Œ. senegalensis* Kr. and *Œ. abruptus* Sauss. From both of these it differs in the acute angle of the posterior border of the pronotum, at least in the male (this angle is more obtuse in the female). I have drawn up the description on the model of de Saussure's synoptical table, in which he distinguishes these two species.

Acrotylus longipes (Charp.).

Somaliland (1895 or 1897), one female. West Somaliland (1895), one male and two females.

These specimens are the red variety, the same as recorded by me from Sokotra (P. Z. S. 1898, p. 384).

Pyrgomorphidæ.

Chrotogonus lugubris Blanch.

Somaliland (1895 or 1897). One male, two larvæ.

Phymateus stollii Sauss.

North-west Somaliland, Whardi Datal, July 26, 1895. Two males and two females.

Ph. morbillosus Serv. ?

North Central Somaliland: Haud, Odewein, June 23, 1897. Two larvæ. ("Dry river, thickly wooded banks."—C. V. A. P.)

I refer these larvæ with some hesitation to *P. morbillosus*.

Pyrgomorpha grylloides (Latr.).

North-west Somaliland: Whardi Datal, July 26, 1895. One female.

Acridiidæ.

Schistocerca peregrina (Oliv.).

North-west Somaliland: Gooban District, between Hargaisa and Berbera, August 6, 1895. Six males, one female.

North Central Somaliland: Haud, Odewein, July 23, 1897. Four nymphs. ("Dry river, thickly wooded banks."—C. V. A. P.) Also five very young larvæ.

Acridium succinctum Serv.
(nec Linn. = *ruficorne*, Serv. et Stål).

West Somaliland (1895). One male and one female.

Sauracris, gen. nov.

Corpus apterum, depressum, granulatum, nitidum. Oculi prominuli, a supero visi, subcontigui. Frons reclinata ; antennæ filiformes. Pronotum deplanatum, carinis nullis, sulcis 3 instructum, margine postico subsinuato, lobis deflexis marginibus antico et postico obliquis, inferiore subrecto. Elytra minima,

rudimentaria vel nulla. Alæ nullæ. Abdomen segmentis 1° et 2° deplanatis, ceteris compressis, carinulatis. Pedes crassiusculi. Femora postica valde incrassata, haud serrulata; tibiæ posticæ margine externo 6–8, interno 8–9 spinis armatæ; tarsi postici segmentis 1° et 3° elongatis, 2° parvo. Cerci ♂ breves, compressi, conici, apice obtusi. Lamina supraanalis ♂ obtusa, apice paullo bi-emarginata, medio plus minus sulcata. Lamina subgenitalis ♂ magna, fornicata; lamina subgenitalis ♀ simplex. Valvulæ ovipositoris breves, granulatæ. Corpus glabrum, partibus genitalibus ♂ ♀ tibiis posticis hirsutis.

This new genus falls into the group *Coptacræ*. The absence of elytra, wings, and of the carinæ of the pronotum separate it from *Cyphocerastes* Karsch, *Epistaurus* Bol., *Acridoderes* Bol.

Sauracris lacerta, sp. n. (Plate II. fig. 3, ♂.)

Statura mediocri, testacea, nigro varia. Caput pallide testaceum; oculi globosi, badii. Pronotum pallide testaceum, fasciis 3 fuscioribus longitudinalibus ornatum. Elytra minutissima, granulati, lobiformia, segmenti abdominalis primi dimidium vix attingentia, vel nulla. Abdomen testaceum, vittis et maculis nigris ornatum. Pedes testacei; femora postica extus fusco vel atro ornata; tibiæ posticæ spinis extus 6–8, intus 9 armatæ. Abdomen subtus nigro variegatum. Femina mare major, fuscior. ♂ ♀.

	♂.	♀.
Long. corporis	25·5 mm.	39 mm.
„ pronoti	6	8
„ elytrorum (si adsunt)..	1·75	1·75
„ femorum posticorum ..	13–13·5	17

Patria. North-west Somaliland, Hargaisa, April 25–28, 1895; 1 male, 1 female and 1 nymph. Central or East Somaliland (1897); 2 males. Female, type from Hargaisa, in Hope Collection, Oxford. Male type from Central or East Somaliland, in Hope Collection. Co-types at Oxford and in the collection of Malcolm Burr.

Locustodea.

Phaneropteridæ.

Peronura sp. inc.

North-west Somaliland, Whardi Datal, July 26, 1895. One female nymph.

It is impossible accurately to determine this immature specimen.

Phaneroptera punctulata, sp. n.

Parva, læte viridis; pronoto, cruribus, abdomine nigro-punctulatis. Pronotum lobis deflexis æque altis ac longis; carinæ haud valde expressæ, flavidæ. Elytra breviora, venulis transversis haud prominulis, parte anali usque ad apicem nigro-punctulata. Alæ elytris longiores. Femora postica gracilia, apicem elytrorum

superantes, basi incrassata. Lamina supraanalis ♂ oblonga. Cerci ♂ longi, teretes, acuminati, apice mucronati. Lamina subgenitalis ♂ elongata, triangulariter emarginata, cercos haud superans. ♂.

	♂.
Long. pronoti	12·5 mm.
„ corporis	4
„ alarum	23·75
„ elytrorum	14·75
Lat. elytrorum medio	2·75
Long. femorum posticarum	16

Patria. North-west Somaliland, Whardi Datal, July 26, 1895. One male. Type in Hope Collection, Oxford.

This species comes nearest to *Ph. nana* Charp., but may be distinguished by the absence of the basal spots of the elytra, which also separates it from *Ph. quadripunctata* Br. The minute black dots all over the body resemble those of *Leptophyes punctatissima*, Bosc.

MILITITSA, gen. nov.

In tribum *Terpnistriarum* locandum. ♂ ignotus.

Fastigium verticis sulcatum et compressum. Frons brevis, perpendicularis. Oculi valde globosi. Pronotum sellæforme, disco antice elevatum, obtusum, postice deplanato, margine ipso subelevato, rotundato, carinis lateralibus nullis; lobis deflexis altioribus quam longioribus, marginibus rotundatis. Elytra angusta, paullo ante medium latiora, dehinc attenuata, margine postico sinuato, apice oblique truncata; venæ 2 radiales subcontiguæ, apicem versus divergentes, ramis 1–3 venæ ulnaris conjunctis, ramo ultimo in marginem apicalem elytri ecurrente; vena ulnaris a vena radiali valde remota, in marginem posticum elytri deflexa, ramos nonnullos furcatos albo-circumdatos venam radialem versus emittens, quorum postremi ramis venæ radialis conjuncti; campus analis basi latus, dehinc angustissimus, venulis rectis transversis plurimis instructis, in tertia parte apicali elytri evanescens; campus marginalis latus, ad conjunctionem venæ radialis anterioris cum margine antico productus; intra marginem per totam longitudinem elytra anguste decolor, hyalinus. Alæ elytris longiores. Coxæ anticæ spina nulla instructæ. Femora omnia teretes, postica subtus spinulis 3 armata, lobis genicularibus acuminatis; tibiæ anticæ et intermediæ compressæ, margine postico spinulis minimis armatæ. Tibiæ anticæ utrinque foramine aperto, oblongo, instructæ; tibiæ posticæ per totam longitudinem utrinque supra spinis albidis, apice rufescentibus, armatæ. Meso- et metasternum lobis obtusis instructa. Ovipositor satis magnus, sensim incurvis, apice obtusus, valvula superiore minime crenulato, valvulam inferiorem muticam superans. ♀.

This genus may be at once separated from *Terpnistria* Stål by the unspined pronotum and unlobed legs. The unarmed coxæ

and open tympana of the anterior tibiæ distinguish it from *Diogena* Br.

Milititsa somaliensis, sp. n. (Plate II. figs. 5 & 7.)

Corpus ferrugineum. Caput et pronotum viridia. Elytra viridia, venulis transversis hyalino-circumdatis, margine antico hyalino, margine postico sordide ferrugineo. Ovipositor nitidus, viridis, apice infuscatus. Cerci recti, conici. Lamina subgenitalis ♀ parva, apice angusta, truncata. ♀.

	♀.
Long. corporis	20·5 mm.
„ pronoti	4
„ elytrorum	27
„ femorum posticorum	17
„ ovipositoris	11

Patria. North-west Somaliland, Whardi Datal, July 26, 1895. One female specimen. Type in Hope Collection, Oxford.

Tylopsis perpulchra, sp. n.

Viridis, elongata. Pronotum dorso deplanatum, viride, minutissime fusco-punctulatum, marginibus antico et postico subsinuatis, carinis lateralibus rectis, parallelis, albis, antice subtus atro-marginatis; lobi deflexi angulato inserti, margine inferiore recto, angulo postico retroproducto, margine postico valde sinuato, antico perpendiculari. Elytra elongata, angusta, lanceolata, ramo primo venæ radialis apice furcato, viridia, antice late albo-marginata, vitta pallide purpurea intra, apicem versus attenuata ornata. Alæ elytris valde longiores, venis radialibus mediis valde infuscatis. (Pedes antici et intermedii desunt.) Pedes postici gracillimi, longissimi, fusco-testacei. Cerci longi, validi, apice valde undulato-incurvi, apice decussati et infuscati. Lamina subgenitalis ♂ elongata, apice triangulariter excisa. ♂.

	♂
Long. corporis	20 mm.
„ pronoti	3·5
„ elytrorum	28
„ femorum posticorum	28

Patria. North-west Somaliland, Whardi Datal, July 26, 1895. One male specimen. Type in Hope Collection, Oxford.

This species agrees with *T. bilineolata* Serv. in the straight inferior borders of the side flaps of the pronotum, but may be distinguished by the variegated elytra.

Otiaphysa angustipennis, sp. n. (Plate II. fig. 2.)

Flavo-ferruginea; elytra, alarum apices, virides; elytra venulis transversis albido-circumdatis, margine antico valde sinuato, margine postico recto, paullo ante medium latiora, pone medium valde angustata, apice oblique truncata. ♀.

	♀.
Long. corporis	26 mm.
,, pronoti......................	5
,, elytrorum	40
Lat. max. elytrorum ante medium	9
,, ,, prone medium	6
Long. ovipositoris	5·75

Patria. North-west Somaliland, Whardi Datal, July 26, 1895. One female specimen. Type in Hope Collection, Oxford.

This species differs from *O. hebetata* Karsch in its smaller size, narrowed elytra, and slightly longer ovipositor. In *O. hebetata* the elytra attain their greatest breadth (12 mm.) just before the apex; in this species, in the first half of the elytra.

RHEGMATOPODA PEELI, sp. n. (Plate II. fig. 1.)

Pallide virescens. Pronotum disco infuscato. Elytra translucida, longiora. Alæ elytris longiores. Pedes graciles; femora antica et intermedia subtus utrinque spinulosa; tibiæ anticæ et intermediæ triseriatim spinulosæ. (Femora postica desunt.) Elytra venæ radiales basi remotæ, dehinc appropinquantes, subcontiguæ, deinde divergentes, vena postica ramum furcatum in apicem elytri emittens; vena ulnaris sinuata; area analis magis explicata; venulæ transversæ omnes rectæ, parallelæ; campus tympanalis valde prominulus. Lamina supraanalis ♂ brevis, rotundata. Cerci ♂ laminam subgenitalem multo breviores, acuminati, mucronati. Lamina subgenitalis ♂ elongata, deplanata, apice triangulariter emarginata, lobis obtusis. ♂. ♀ ignota.

	♂.
Long. corporis..........	19 mm.
,, pronoti	5·75
,, elytrorum	34

Patria. North-west Somaliland, Whardi Datal, July 26, 1895. One male specimen. Type in Hope Collection.

Tabula specierum generis Rhegmatopodæ.

1. Elytra campo marginali sensim angustato, tertia parte apicali evanescenti, vena ulnari decurva; area ulnaris (pone venam ulnarem) sat lata. Pronotum lobis deflexis, margine postico vix sinuato, margine infero convexo. Femora mutica .... 1. *leptocerca* Stål.
2. Elytra campo marginali latiori, apicem elytri attingenti; vena ulnari sinuata, undulata, apice recurva, area ulnari latissima. Pronotum lobis deflexis, margine postico valde sinuato, margine infero obliquo. Femora antica et intermedia subtus spinulosa .... 2. *peeli*, n. sp.

EURYCORYPHA VARIA Brunner.

Patria. North-west Somaliland, Whardi Datal, July 26, 1895. One female. Recorded from Kilimanjaro by Brunner.

CONOCEPHALIDÆ.

XIPHIDIUM SOMALI, sp. n.

X. natalensi *Redt. vicinum. Fastigium verticis ab antico visum lateribus haud distincte divergentibus. Caput et pronotum flava, fasciis tribus, media lata, lateralibus angustis fuscis ornata; pronotum inerme, lobis deflexis obtuse triangularibus, marginibus obliquis, vix sinuatis, callo convexo nullo. Elytra abbreviata, lobiformia, pronoto breviora, testacea, margine antico infuscato. Alæ obliteratæ. Abdomen fusco-testaceum, utrinque flavido-bilineatum. Femora postica inermia, genibus inermibus. Pedes testaceis. Ovipositor longissimus, rectissimus. Lamina subgenitalis ♀ apice truncata. ♀. ♂ ignotus.*

		♀.
Long. corporis	....	17·5 mm.
„ pronoti	....	3·5
„ elytrorum	....	3
„ ovipositoris	....	·8

Patria. North-west Somaliland, Whardi Datal, July 26, 1895. One female specimen. Type in Hope Collection, Oxford.

This species differs from *X. natalense* Redt. in its unarmed knees and differently coloured head and pronotum. From *X. brevicercus* and *X. armaticeps* Karsch it may be distinguished by its unarmed head and pronotum.

HETRODIDÆ.

EUGASTER LORICATUS Gerst.

North Central Somaliland: Haud District, Eyk ("in open plain by thick bush"), July 2–4, 1897. One male and one female specimen.

SPALACOMIMUS TALPA (Gerst.).

North Central Somaliland: Haud District, Eyk, July 2–4, 1897. ("Open plain by thick bush."—C. V. A. P.) One male and one female specimen.

STENOPELMATIDÆ.

MAGRETTIA OBSCURA, sp. n.

Fusco-testacea, nitida. A M. abominata *Br. differt femoribus tantum spinula minima unica apicem versus armatis, tibiis anticis inflatis. A* M. mutica *Br. differt femoribus spinula unica, neque 4–5 armatis, pronoto antice quam postice paullo latius.* ♂.

	♂.
Long. corporis..........	22 mm.
„ pronoti	5·5
„ fem. post.	16·5

Patria. North Central Somaliland: Haud District, Eyk ("on open plain by thick bush"), July 2–4, 1897. One male specimen. Type in Hope Collection, Oxford.

This species seems to be a link between *M. abominata* Br. (African), which has many-spined femora and compressed anterior tibiæ, and the pronotum slightly broader anteriorly than posteriorly, and *M. mutica* Br. (Asiatic), in which the femora have only 4–5 minute spines beneath, while the anterior tibiæ are sub-inflated and the pronotum is cylindrical.

GRYLLODEA.

GRYLLIDÆ.

LIOGRYLLUS BIMACULATUS (De Geer).

North-west Somaliland, Hargaisa, April 25–28, 1895. Four female specimens.

GRYLLUS sp.?

North-west Somaliland, Hargaisa, April 25–28, 1897. One female, one nymph. Both specimens are too mutilated for determination. The elytra are abbreviated, and the ovipositor is as long as the body. The general colour is dull black.

GRYLLUS MELANOCEPHALUS Serv.

North-west Somaliland, Hargaisa, April 25–28, 1895. One male specimen. Possibly only a dark variety of *G. domesticus*.

GRYLLUS LUGUBRIS Stål (=*G. afer* var.?).

North-west Somaliland, Hargaisa, April 25–28, 1895. One male specimen.

8. INSECTS OF OTHER ORDERS.

By various Contributors.

[Mr. Peel also brought several Hymenoptera and a few Hemiptera. The known species of the former have been kindly identified by Mr. W. F. Kirby, of the latter by Mr. W. L. Distant.

E. B. POULTON.]

HYMENOPTERA.

Terebrantia. *Entomophaga.*

BRACONIDÆ.

BRACON sp. A single specimen (1897).

Aculeata. *Heterogyna.*

FORMICIDÆ.

PALTOTHYREUS PESTILENTIUS (Smith).

Three specimens from Bularli (West Somaliland), May 25, 1895. Mr. Peel describes the species as excessively abundant at this locality.

Fossores.

MUTILLIDÆ.

MUTILLA ARENARIA (Fabr.).

A single female specimen (1897).

POMPILIDÆ.

SALIUS MEGAERA (Smith).

A single specimen from the Webbi Shebeyli, near Mount Kuldush, June 28, 1895.

LARRIDÆ.

LARRADA sp. allied to *L. diabolica* (Smith).

A single specimen from Sibi (West Somaliland), May 27, 1895.

Diploptera.

EUMENIDÆ.

EUMENES LEPELLETIERI (Sauss.).

Seven specimens from Eyk, in the Haud District of North Central Somaliland, July 2–4, 1897. "Open plain by thick bush" (C. V. A. P.).

EUMENES DIMIDIATIPENNIS (Sauss.).

A single example from West Somaliland (1895).

RHYNCHIUM sp.

Two specimens from the Bun Feroli, north of the Webbi Shebeyli, June 10–20, 1895.

Anthophila.

APIDÆ

XYLOCOPA sp. near to *flavilabris.*

A single example (1897).

APIS LIGUSTICA (Spin.).

Eight specimens from the Haweea Country in East Central Somaliland, Sept. 8–27, 1897. (W. F. K.)

Hemiptera.

Two species of Rynchota Hemiptera were obtained by Mr. Peel.

Odontopus sexpunctatus (Lap.).

One specimen from Bularli in West Somaliland, May 25, 1895; and others from the 1897 Expedition in Central and East Somaliland (no further locality).

Two specimens of another species in bad condition were also obtained in 1897. (W. L. D.)

9. CHILOPODA AND ARACHNIDA.

By R. I. Pocock.

The Arachnida collected by Mr. Peel proved on examination to be exceptionally interesting. Of the six species of Acari, two of the parasitic species of the genus *Rhipicephalus* seem to be well-marked new forms. One of them is represented by both males and undistended females; the other unfortunately by a single male, but this specimen differs so strikingly in colour from all the species of the genus recently recorded in Neumann's useful monograph of the group, that I have not hesitated to describe it as new. Mr. Peel was even more fortunate with his Scorpions. He collected only five specimens; but they represent four species, three of which have never been previously described. Two of these, *Buthus calviceps* and *Pandinus pugilator*, are exceptionally well-marked forms; while the third species, which I have dedicated to Mr. Peel, belongs to a section of the genus peculiar to Somaliland and hitherto represented by a single species.

The working out of this material has entailed a revision of the Scorpions of Somaliland, based upon those contained in the collection of the British Museum. The results have been incorporated in a supplement to the report upon Mr. Peel's collection, in the hope that sportsmen and naturalists who visit this country may see at a glance what is known of these animals and may be induced to follow, so far as collecting is concerned, the examples of Messrs. Lort Phillips, Donaldson Smith, and Peel.

Class CHILOPODA.

Family Scolopendridæ.

Two representatives of this family were obtained, April 25–28, 1895, at Hargaisa, North-west Somaliland, namely *Ethmostigmus trigonopoda*, a species which is distributed throughout tropical Africa, and a damaged example of a species of *Rhysida* probably referable to *R. paucidens*, Pocock[1], originally procured at Loga in the Arusi Galla country, but the absence of the anal legs makes the determination doubtful.

The specimens of these species are in the Hope Museum at Oxford.

[1] In Donaldson Smith's 'Through Unknown African Countries,' p. 404 (1897).

Class ARACHNIDA.

Order Acari.

Family Trombidiidæ.

Genus Trombidium.

Trombidium tinctorium (Linn.), Trouess.

Trombidium tinctorium, Trouessart, Ann. Soc. Ent. France, 1894, pp. 89–91 & 94, fig. *a*.

Loc. Hargaisa in North-west Somaliland (April 25–28, 1895). Two specimens in the Hope Museum at Oxford.

Family Argasidæ.

Genus Ornithodoros Koch.

Ornithodoros savignyi (Aud.).

Argas savignyi, Aud., Description de l'Egypte, Hist. Nat. i. pl. iv. fig. 5; Explanation of Plates, p. 183 (1827).

Ornithodoros savignyi, Neumann, Mém. Soc. Zool. France, x. p. 26 (1897).

Loc. Bularli in West Somaliland (May 1895). Six specimens, two in the British Museum, the rest in the Hope Museum at Oxford.

Family Ixodidæ.

Genus Hyalomma C. Koch.

Hyalomma grossum C. Koch.

Hyalomma grossum, C. Koch, Arch. Natur. x. i. p. 220, no. 2, Uebersicht etc. iv. p. 34, pl. ii. fig. 8 (1847).

Loc. Bularli in West Somaliland (May 1895).

A single distended female, probably referable to this species; in the Hope Museum at Oxford.

Genus Rhipicephalus C. Koch.

Rhipicephalus sanguineus (Latr.).

Ixodes sanguineus, Latreille, Hist. Nat. Crust. Ins. i. p. 157 (1804).

Rhipicephalus sanguineus (Latr.), Neumann, Mém. Soc. Zool. France, x. p. 385 (1897).

Loc. Bularli in West Somaliland (May 1895).

Three specimens, one in the British Museum and two in the Hope Museum at Oxford.

RHIPICEPHALUS MARMOREUS, sp. n. (Plate III. figs. 1–1 *d*.)

♂. *Colour.* Capitulum yellowish brown; dorsal surface of body yellowish white, with five large deep red-brown patches, one on each side extending backwards from the cervical groove, one on each side longitudinal and sending off towards the middle line a broad transverse bar, and a large posterior median patch with convex hinder border and anterior border produced forwards in the middle line, also a narrow brown band running round the margin of the dorsal scute; legs yellowish brown, with a broad longitudinal white band on the upperside of the femora, patellæ, and tibiæ; ventral surface of body whitish, with chitinous sclerites deep brown like the legs.

Posterior border of *capitulum* evenly concave, the angles moderately produced; lateral margins moderately, not strongly diverging, the anterior border only a little wider than the posterior.

Dorsal plate almost entirely covering the sides of the body, leaving merely a narrow marginal membranous rim; cervical grooves distinct, short; marginal groove represented by a series of coarse punctures; three posterior punctured grooves on the posterior dark patch; for the rest the dorsal plate is without grooves but is pitted with coarse scattered punctures; the posterior rim divided by short sulci into eleven festoons. Ventral area with a single long piriform adanal plate, which is narrowed in front and extends backwards almost to the posterior coxæ; its external border slightly convex, internal border concave in the middle, convex in the anterior and posterior third, posterior border oblique and ending internally in a rounded rectangular prominence; a single small median sclerite on the postanal membranous area. *Coxæ* of anterior legs produced into two strong spiniform processes; of 2nd to 4th with a single distal spiniform process on the posterior side.[1]

Total length of dorsal plate 3·8 mm.

Loc. Bularli in West Somaliland (May 1895).

A single specimen (♂ type) in British Museum.

RHIPICEPHALUS ARMATUS, sp. n. (Plate III. figs. 2–2 *f*.)

♂. *Colour* a tolerably uniform deep brown, with black markings on the grooves of the dorsal plate; legs deep brown; ventral area pale.

Capitulum with posterior border straight in the middle, its angles more abruptly spiniform than in *R. marmoreus*, its lateral margins more obliquely diverging in their posterior two-thirds, then abruptly converging. *Dorsal scute* not quite covering the lateral area, with normal cervical grooves; marginal groove deep, strongly pitted, extending from a point on a level with the cervical groove to the beginning of the festoons of the posterior border; posteriorly there is a pair of deep pitted grooves, and between

[1] Owing to the dried state of the specimen, satisfactory examination of the mandibular armature was impossible.

them and the marginal groove on each side another similar but curved groove which extends from in front of the middle of the dorsal area back as far as the posterior end of the marginal groove; in addition to the punctures in the grooves there are a few coarse punctures scattered here and there; posterior border with eleven festoons. *Adanal plates* narrowed in front, but not extending far forwards beyond the anus; their inner border nearly straight, external border convex; posterior border produced into a short external and a long spiniform internal tooth, which projects nearly as far back as the posterior border of the dorsal plate, the apex of this spine is obliquely truncate and subbifid, above it is a second strong spine; a pair of postanal sclerites. *Coxæ* of 1st leg strongly bidentate; of 2nd to 4th also bidentate, the two teeth being on the posterior border, one proximal, the other distal and thinner. Total length 4·8 mm.

Two undistended female specimens, probably referable to this species, have the cephalic plate about as wide as long, reddish in the middle, blackish at the sides, the cervical grooves deep, a row of large punctures representing the marginal grooves on each side, some large punctures along the lateral edge in front of the eye, a few between the cervical grooves, and a few large ones and many smaller ones on the middle of the posterior area. The *abdomen* is impressed posteriorly with three shallow grooves and is obsoletely festooned. *Coxæ* of the legs posteriorly weakly bispinate, the external spine being the larger.

Loc. Bularli in West Somaliland (May 1895).

Six specimens. Type (male) and two co-types (male and female) in the British Museum. Three co-types (2 males and 1 female) in the Hope Museum at Oxford.

The males of the three species of this genus obtained by Mr. Peel may be determined as follows:—

(♂) *a.* Dorsal plate marked behind with a pair of moderately long grooves, one on each side of the middle line; between these and the deep marginal groove there is a third long and deep groove extending from the second or third sulcus of the festooned border past the middle of the dorsal plate; adanal plate produced behind into a long and strong spiniform process, immediately above which there is a second strong spine; a pair of chitinous postanal sclerites .... *armatus.*

b. Dorsal plate with a longish posterior median sulcus and a pair of shallower impressions, one on each side of it, with only a very short shallow and inconspicuous groove between the marginal groove and the middle line; adanal plate not produced behind into a long spiniform process; no spine above the termination of this plate.

a′. Dorsal plate yellowish white, with large symmetrically disposed reddish-brown patches; legs brown, painted with white above; dorsal plate sparsely punctured; marginal groove represented by a series of punctures. *marmoreus.*

b′. Dorsal plate deep brown with blacker patches and yellow lateral margin; legs uniformly brown; dorsal plate closely and irregularly punctured; marginal groove distinct .... *sanguineus.*

Order ARANEÆ.

Unfortunately the few Spiders obtained by Mr. Peel were not all preserved in such a manner as to make their specific determination possible, being dried, pinned, and for the most part very much shrivelled. The following forms, however, are recognizable.

1. ARANEUS HOPLOPHALLUS Poc. (Bull. Liverpool Museum, ii. p. 40, 1899.)

An adult male certainly belonging to this species and a female doubtfully referred to it, the former from Berbera in North-west Somaliland, the latter from East Central Somaliland (1897). The type was procured in Sokotra and is preserved in the British Museum; the specimens procured by Mr. Peel are in the Hope Museum.

2. ARANEUS NAUTICUS L. Koch.

A single female, most likely of this species, from Berbera, in the Hope Museum.

3. CEBRENNUS ÆTHIOPIUS Simon.

A single immature female, probably referable to the Abyssinian species, was taken in Eastern Central Somaliland. In the Hope Museum.

4 & 5. OXYOPES sp.?

Two specimens from Western Somaliland, each representing an indeterminable species. In the Hope Museum.

Order SCORPIONES.

Family SCORPIONIDÆ.

Genus PANDINUS Thorell.

PANDINUS PUGILATOR, sp. n. (Plate IV. figs. 1, 1 *a*.)

Colour of chelæ, tail, and upperside of body olive-brown, the hands rather paler; legs and vesicle of tail clear pale yellow.

Carapace smooth, sparsely punctured above, granular at the sides, its length exceeding that of the movable digit and almost equalling that of the 3rd and 4th tail-segments.

Tergal plates granular laterally; the last more or less granular throughout. *Sternal plates* smooth, the last weakly crested.

Tail short and slender, less than three times the length of the carapace, considerably narrowed posteriorly; the 4th segment about twice as long as wide, the 5th considerably more than twice as long as wide; 1st segment weakly granular above, for the rest smooth, all its keels smooth; 2nd segment entirely smooth, 3rd with the four inferior keels strong, rugose, the intervening spaces granular; 4*th with the infero-lateral keels strong and denticulated*,

the inferior median keels not differentiated amongst the coarse granules covering the lower surface of the segment; 5th segment with the inferior keels denticulated, the area between them coarsely granular; upperside of the 3rd, 4th, and 5th segments smooth, the keels also smooth or at all events only roughened with pores; *vesicle* granular, narrow, its width equal to its height and only about one-third the length of the vesicle and aculeus.

Chelæ: humerus coarsely granular above, its anterior surface with strongly granular crests; lower surface granularly crested behind; brachium finely granular in front, also roughened with pores and granules behind; hand wide, its width about equal to the length of the movable digit, its upper surface smooth posteriorly on the lobe, the area just above external keel coarsely granular, the rest covered with low more or less anastomosing tubercles, which are, however, more distinct towards the base of the immovable digit; the inner edge smooth, though the granules of the lower surface run right up to it or even project slightly beyond it; the lower surface sparsely granular, with two weakly defined keels; keel defining the hand-back above very strong and prominent.

Legs smooth; protarsal segment of 1st and 2nd with a single external apical spine; tarsi armed with eight spines, two on each side being on the lobe, one on its lower angle, the other in the middle as in *P. colei*, *P. bellicosus*, &c.

Pectinal teeth 17.

Measurements in millimetres. Total length 93; length of carapace 18, of tail 48; width of 1st segment 5·8, of 4th 3·5, of vesicle 3·2; width of hand 16, length of movable digit 17.

Loc. North-west Somaliland (Berbera or Hargaisa). A single specimen (type) in the British Museum.

Recognizable by the granulation of the lower side of the 4th caudal segment and the obsoleteness of its inferior median crests, &c.

PANDINUS PEELI, sp. n. (Plate IV. fig. 2.)

♂. Closely allied to *P. colei* (Pocock), but differing in the characters pointed out in the table given below (*cf.* p. 62).

Carapace quite smooth above, sparsely punctured, much less closely granular laterally than in *P. colei*. *Terga* weakly granular at the sides only, not closely granular throughout the posterior half as in *P. colei*. *Chelæ* larger than in *P. colei*; upper crest of brachium smooth; upperside of hand externally granular as in *P. colei*, but internally much smoother, the granules anastomosing and running together into ridges which become almost obsolete on the posterior lobe of the hand. Fourth abdominal *sternum* obsoletely granular in the middle. *Pectinal teeth* 15.

Measurements in millimetres. Total length 81; length of carapace 14·5, of tail 38, of underhand 10; width of hand 13·5.

Loc. North-west Somaliland (Berbera or Hargaisa). A single specimen (type) in the British Museum.

Family Buthidæ.

Genus Uroplectes Peters.

Uroplectes fischeri (Karsch).

Lepreus fischeri Karsch, Mitth. Münch. ent. Ver. 1879, p. 124.

The two specimens of this species that were obtained in North-west Somaliland (at Berbera or Hargaisa) agree closely in characters with those collected by Dr. Donaldson Smith at Lummo and Turfa, and discussed on pp. 400–401 of that author's account of his expedition. One of Mr. Peel's specimens is in the British Museum, the other in the Hope Museum at Oxford.

Genus Buthus Leach.

Buthus calviceps, sp. n. (Plate IV. figs. 3–3 *a*.)

Colour (dry specimen): trunk blackish yellow; appendages uniform pale yellow.

Carapace weakly granular; keels almost entirely obsolete, only the anterior median distinct but failing to attain the front border of the carapace. *Tergal plates* rather coarsely granular; keels normal and granular. *Sternal plates* smooth and polished; the last very finely granular at the sides, polished and rather coarsely but sparsely punctured in the middle; the lateral keels almost obsolete, represented by about three larger granules.

Tail of medium thickness, nearly five times the length of the carapace, posteriorly narrowed; the sides and upper surface of the segments normally crested, the intercarinal spaces finely granular; the median lateral keel complete on the 2nd and almost complete on the 3rd segment; lower surface of 1st, 2nd, and 3rd segments rather coarsely but strongly punctured with setiferous pores; the median keels of the 1st obsolete, those of the 2nd and 3rd strong and denticulated, increasing in strength posteriorly, the inferior laterals of these segments also strong and denticulated, converging posteriorly and fusing, like the medians, with a transverse granular crest; lower surface of the 4th weakly granular, without median keels; 5th segment without a trace of superior lateral keels, finely granular below, with a few coarser granules intermixed, the median keel denticulated; the laterals strongly denticulated, with at least one large lobate tooth behind the middle of their length, ending behind in a big subdivided lobe on each side of the anal aperture; *vesicle* of medium size, smooth, punctured.

Chelæ weak; humerus granular above, normally crested; brachium smooth, weakly crested, anterior surface with two weakly granular keels; hand smooth, small, narrower than brachium, movable digit with eight rows of teeth along the middle line, the basal row long and rising right at the extremity of the segment, the lateral teeth forming short oblique rows of three each, two

outer and one inner; finger a little more than twice the length of the underhand.

Legs with granularly crested femora; the feet with two rows of hairs below.

Pectinal teeth 21.

Genital operculum considerably longer than sternum.

Measurements in millimetres. Total length 31; length of carapace 3·5, of tail 17·5; length of movable digit 3.

Loc. North-west Somaliland (Berbera or Hargaisa). A single specimen (type) in the British Museum.

In size and some points of structure this little *Buthus* approaches *Nanobuthus andersoni* Poc., obtained at Duroor to the north of Suakim (Journ. Linn. Soc., Zool. xxv. p. 314). The dentition of the mandible and of the digits of the chelæ, however, is quite normal for the genus *Buthus.* The most striking structural peculiarities of the species are: (1) the obsoleteness of all the cephalothoracic keels with the exception of the anterior median: (2) the coarse but sparse punctuation of the last sternite and of the lower side of the first caudal segment, accompanied as it is by the disappearance of the median keels; (3) the disappearance of the median keels on the lower side of the 4th caudal segment. These characters do not co-exist in any species known to me. Judging from the structure of the inferior lateral keels of the 5th caudal segment and of the inferior keels of the 2nd and 3rd segments, this species belongs to the same category as *B. occitanus.*

10. General List of the Scorpions of Somaliland and the Boran Country. By R. I. Pocock.

Family Buthidæ.

Genus Uroplectes Peters.

Uroplectes fischeri (Karsch).

Lepreus fischeri, Karsch, Mitth. Münch. ent. Ver. iii. p. 124 (1879).

Loc. Barawa (*Karsch*), Turfa and Lummo (*Donaldson Smith*), and Berbera and Hargaisa (*C. V. A. Peel*).

To the south of Somaliland the typical form of this species is replaced by two subspecies, one paler, the other darker than *U. fischeri typicus.* The three may be contrasted as follows:—

a. Hands entirely pale, body banded above as in *fischeri typicus* .... *fi. flavimanus*, subsp. [nov.
b. Hands wholly black or at least lined with black and black at base of fingers.
  a′. Terga yellow, with a pair of black spots; carapace and terga broadly yellow at the side ... *fi. typicus.*
  b′. Terga mostly black, with a narrow median and lateral marginal band, much less yellow at side of carapace............................... *fi. nigrimanus.*

The subspecies *nigrimanus* was based upon a single example from Mombasa (see Proc. Zool. Soc. 1890, p. 130, pl. xiv. fig. 2). *U. flavimanus* is based upon a specimen in the British Museum obtained by Mr. J. Wilson at Mombasa in British East Africa.

It is interesting to note that the two subspecies most distinct from each other, namely, *U. f. flavimanus* and *U. f. nigrimanus*, occur in the same locality, whereas the subspecies intermediate between them is found elsewhere.

Genus Parabuthus Pocock.

Parabuthus granimanus Pocock.

Parabuthus granimus, Pocock, Journ. Linn. Soc., Zool. xxv. p. 311 (1895).

Loc. Zeyla in North-west Somaliland (*E. W. Oates*), Goolis Mountains (*Lort Phillips*). In the British Museum.

Parabuthus heterurus Pocock.

Parabuthus heterurus, Pocock, in Donaldson Smith's 'Through Unknown African Countries,' p. 402 (1897).

Loc. Hargaisa, Silul, Shebeli River (*A. Donaldson Smith*); Goolis Mountains (*E. Lort Phillips*). In British Museum.

The two species of this genus may be recognized as follows:—

a. Hand and brachium closely granular; 5th segment of tail strongly infuscate at least below .... *P. granimanus.*
b. Hand and brachium smooth, punctured, hairy; 5th caudal segment clear yellow throughout, 4th segment and vesicle black .... *P. heterurus.*

Genus Buthus Leach.

Buthus occitanus (Amoreux), subsp. nov. berberensis.

Colour yellow, with black lines along the keels of the upperside of the trunk, humerus, brachium, and hand, also the distal half of the femora infuscate and the base and keels on the patellæ. *Body* and *tail* crested and granular as in the typical form, the granules of the inferior keels of the 2nd and 3rd caudal segments about as much enlarged as in the Spanish form; external surface of hand with a few granules, a pair of strong granular finger-keels running along its upperside and inner edge.

Total length 38 mm.

Somaliland (*Miss Gillett*). In British Museum.

Subsp. nov. zeylensis.

Colour a uniform reddish yellow, the appendages and tail clearer than the trunk. Frontal intercarinal area of *carapace* covered with granules; a median row of granules running along

the middle of the ocular tubercle. *Terga* closely and finely granular throughout. Inferior keels of 2nd and 3rd *caudal segments* strongly dentate. *Hand* smooth, with a pair of weak and weakly granulate crests on its upperside.

Total length 50 mm.

Loc. Zeyla in North-west Somaliland (*E. W. Oates*). In British Museum.

BUTHUS CALVICEPS Poc.

Cf. supra, p. 54.

BUTHUS ACUTECARINATUS Simon.

Buthus acutecarinatus, Simon, Ann. Mus. Genova, xviii. p. 245, pl. viii. fig. 18 (1883).

Loc. Zeyla (*E. W. Oates*). In British Museum.

Occurs also in Egypt and Arabia.

BUTHUS POLYSTICTUS Poc.

Buthus polystictus Pocock, Ann. Mag. Nat. Hist. (6) xviii. p. 178, pl. xi. fig. 1 (1896).

Goolis Mountains in Somaliland (*E. Lort Phillips*). In British Museum.

BUTHUS EMINI Pocock.

Buthus eminii, Pocock, Ann. Mag. Nat. Hist. (6) vi. p. 98 pl. i. fig. 2 (1890) ; *id.* op. cit. (6) xviii. p. 179 (1896).

Loc. Aimœa in the Boran Country, 3000 ft. (*A. Donaldson Smith*). In British Museum.

This species and perhaps also *B. polystictus* may prove to be subspecies of *B. trilineatus* Peters, described from Tete.

The species and subspecies of *Buthus* mentioned above may be diagnosed as follows :—

a. Inferior lateral keels of 5th caudal segment posteriorly lobate ; inferior median keels of 2nd and 3rd with the granules enlarged towards the posterior end.

- a^1. Carapace without distinct median, lateral, and posterior keels, inferior keels on 4th caudal segment obsolete .... *calviceps.*
- b^1. Carapace with distinct median posterior and lateral keels, the posteriors turning outwards and uniting with the laterals, inferior keels on 4th caudal segment developed .... *occitanus.*
  - a^2. Legs, chelæ, and body uniformly yellow, not lined with black ; intercarinal ocular area closely granular .... subsp. *zeylensis.*
  - b^2. Chelæ and body with black-lined keels, femora of legs distally infuscate ; patellæ also infuscate basally and along keels ; frontal area of carapace sparsely granular in the middle .... subsp. *berberensis.*

b. Inferior lateral keels of 5th caudal segment and inferior median of segments 2 and 3 uniformly granular throughout.
- a^3. Hand carinate and densely granular; dorsal abdominal keels posteriorly strongly spiniform......... *acutecarinatus.*
- b^3. Hand smooth, not carinate; dorsal abdominal keels not strongly spiniform posteriorly.
  - a^4. Less coarsely granular; tail thinner and lower, height of 4th segment barely half its own length and distinctly less than length of 1st; upper surface of caudal segments much less strongly excavated, &c. .... *polystictus.*
  - b^4. More coarsely granular; tail thicker, its superior keels more strongly elevated; height of 4th segment more than half its length and equal to length of 1st .... *emini.*

Family SCORPIONIDÆ.

Genus PANDINUS Thorell.

PANDINUS MEIDENSIS Karsch.

Pandinus meidensis, Karsch, Mitth. Münch. ent. Ver. iii. p. 127 (1879); Kraepelin, Das Tierr., Scorpiones, &c. p. 119 (1899).

Loc. Meid in Somaliland. In Berlin Museum.

PANDINUS SMITHI (Pocock).

Scorpio smithii, Pocock in Donaldson Smith's 'Through Unknown African Countries,' p. 198 (1897).

Loc. Hargaisa, Silul, Abdeh, and Turfa in Somaliland (*A. Donaldson Smith*). In British Museum.

PANDINUS PALLIDUS (Kraepelin).

Scorpio pallidus, Kraepelin, Mitt. Mus. Hamburg, xi. p. 60 (1894).

Pandinus pallidus, id. Das Tierr., Scorpiones, &c. p. 120 (1899).

Loc. Barawa in Somaliland. In Hamburg Museum and British Museum.

The typical form of this species was based upon immature individuals measuring only up to 75 mm. long. Until the adult is known it seems to me impossible to classify the species with certainty. It is undoubtedly nearly allied both to the following species, *P. phillipsi* from North-west Somaliland, and to the more southern Masailand form *P. gregorii*, but it will probably prove to be at all events subspecifically different from both.

PANDINUS PHILLIPSI (Pocock).

Scorpio phillipsii, Pocock, Ann. Mag. Nat. Hist. (6) xviii. p. 101 (1896).

Pandinus phillipsii, Kraepelin, Das Tierr., Scorpiones, &c. p. 120 (1899).

Loc. Dooloob and the Goolis Mountains, inland of Berbera (*E. Lort Phillips*). In British Museum.

This form is evidently allied to the typical *P. pallidus*; but until adults of the latter come to hand for comparison, it is impossible to say what the exact relationship between the two may be. The original examples of *P. phillipsi* are a pair of females obtained at Dooloob. Mr. Lort Phillips subsequently procured an adult male and a young female on the Goolis Range of mountains. The former has 17–18 pectinal teeth, a longer tail and larger vesicle than the female, and lobate movable finger on the chela. The young one is as large as a co-type of *P. pallidus*, the carapace in the two measuring 11 mm. Moreover the posterior tarsal lobe is tipped above with bristles as in *P. pallidus*, not with a spine as in the adult *P. phillipsi*. But the shape of the hand in the young *P. phillipsi* is different, this organ being very noticeably narrower, and the tubercles on its upperside are much sharper and more strongly defined.

The following actual measurements (in millim.) of the two examples may be advantageously compared:—

	Total length (without vesicle).	Carapace.	Length of brachium.	Length of underhand.	Length of movable finger.	Width of hand.
Young of *P. pallidus*.	71	11	7·5	7	11	10
Young of *P. phillipsi*.	68	11	7·5	7	11	8·5

As will be seen, there is practical identity of measurements[1] except where the width of the hand is concerned.

PANDINUS COLEI (Pocock).

Scorpio colei, Pocock, Ann. Mag. Nat. Hist. (6) xviii. p. 180, pl. xi. figs. 2, 2 *a* (1896).

Pandinus colei, Kraepelin, Das Tierr., Scorpiones, &c. p. 120 (1899).

Loc. Berbera and Goolis Mountains (*E. Lort Phillips*). In British Museum.

This species was based upon a subadult specimen from Berbera.

Mr. Lort Phillips subsequently procured in the Goolis Mountains and kindly sent to the British Museum three additional examples, an adult male and female and a young specimen considerably smaller than the type. The characters upon which the species was based prove perfectly constant. The adult male and female are much alike; the former, however, has the terga of the abdomen finely and closely granular posteriorly, whereas in the female they are nearly

[1] The difference in total length in this and in many other cases is due to the degree of distension of the abdominal region. The length of this region is so very liable to alteration in accordance with the mode of preservation of the specimen after death, and depends so largely upon the fasting or full-fed, pregnant or not pregnant condition of the Scorpion, that the relative lengths of the tail as compared with the trunk, which Kraepelin, Karsch, and others so frequently quote, have but little importance. The length of the carapace, which does not vary, should be taken as standard for comparison.

smooth. Again, the 2nd and 4th abdominal sterna are finely granular in the middle; and, lastly, the vesicle is more strongly inflated, its width considerably exceeding its height and being equal to that of the 4th caudal segment.

In the female the width of the vesicle is scarcely greater than its height and less than the width of the 5th segment.

Pectinal teeth 11–13 (♂ ♀).

Total length (♂) 82 mm., carapace 13·5, tail 38, underhand 8·5, width of hand 12.

PANDINUS PEELI Pocock.

Cf. supra, p. 53.

PANDINUS HAWKERI, sp. n.

Colour of carapace and palpi yellowish brown; tergal plates and tail reddish brown; vesicle brown with yellow lines; legs entirely pale yellow, abdominal sterna testaceous.

Carapace smooth, polished; terga also smooth, punctured along the posterior margin, the last very weakly granular laterally, the crests obsolete. *Sterna*, with exception of the last, smooth; the last obsoletely crested, but mesially closely granular.

Tail short, only a little more than two and a half times the length of the carapace, which is almost as long as its first three segments; the inferior median keels absent on segments 1–5, the inferior laterals present, smooth on segments 1 and 2, granular on 3 to 5, the area of the lower surface of the tail between them granular as in *P. colei*; superior and superior-lateral keels of tail weak, punctured, but not granular; sides of tail smooth; upper surface at most very sparsely granular, except along the posterior edge of segments 1–4, where there is a series of denticuliform granules; *vesicle* strongly punctured and setose beneath, but scarcely granular, its width exceeding its height. *Chelæ*: humerus smooth below and behind, the crests on its upper and anterior surfaces coarsely granular, its upperside sparsely granular in the basal half; brachium smooth, except for some minute granules in front and some coarser ones along the anterior inferior crest: hand moderately wide, its width equal to three-fourths the length of the carapace; upper surface granular on the external slope above the strong keel of the underhand; the rest of the upper surface nearly smooth and polished, beset with a fine reticulation of ridges which are almost obsolete in adult, coarser in young; inner edge almost smooth, punctured, lower surface sparsely and weakly granular towards the base of immovable digit; immovable digit with its basal width less than half the length of its biting-edge; movable digit shorter than carapace, exceeding width of hand, equal to length of 3rd and 4th caudal segments.

Legs smooth; protarsi of 1st and 2nd with one posterior apical spine; tarsal lobes with two spines; lower surface of tarsi with one anterior and three posterior spines; anterior claw much

weaker than posterior. *Sternum* long, about one-third longer than wide.

Pectinal teeth 12–15 in ♀.

Measurements in millimetres. Total length 81, carapace 15, tail 50; width of hand 12; length of movable digit 13, of hand-back 8.

Loc. Jifa Uri inland from Zeyla (*R. M. Hawker*). In British Museum.

Differing from *P. colei* and *P. peeli* in the characters pointed out below (p. 62).

Pandinus pugilator Poc.

Cf. supra, p. 52.

Pandinus militaris, sp. n.

Scorpio bellicosus, L. Koch; Pocock, in Donaldson Smith's 'Through Unknown African Countries,' p. 397 (1897) (nec *P. bellicosus* L. Koch).

♀. *Colour* yellowish brown; legs paler yellow, hand reddish brown with black fingers. *Carapace* granular laterally, entirely smooth above except for a few granules in the anteocular groove. *Terga* finely granular laterally. *Tail* a little more than two and a half times as long as the carapace, the inferior keels on segments 1–3 quite smooth, those on 4th at most slightly rugose; superior and superior-lateral keels of all the segments granular or weakly denticulated; superior surface of 1st granular, of 2nd less so; width of 1st exceeding length of 3rd, almost equal to that of 4th; 5th about twice as long as wide. *Chelæ*: *humerus* granular above at least on its basal half, smooth below; *brachium* almost entirely smooth, its anterior side weakly granular above, more coarsely below; *hand* wide, its width in adult exceeding length of 3rd and 4th caudal segments, inner edge smooth, upper surface smooth, finely reticulated, a few low tubercles just above the keel of the underhand and at the base of the immovable digit; external portion of upper surface rising vertically above keel of underhand; thickness of hand at the front equal to length of 4th caudal segment. Lower side of hand granular distally, scarcely crested.

Pectinal teeth 12–15.

Measurements in millimetres (of type). Total length 112, carapace 19, tail 51; width of hand 16·8, underhand 10·5.

Loc. Aimola in the Boran Country (*Donaldson Smith*); also Ndi, on the Weiss Road inland from Mombasa (*C. Steuart Betton*). In British Museum.

Nearly allied to the East-African species *P. cavimanus*, but differing in the following characters:—the carapace in the female is longer than the 4th and 5th caudal segments, and the basal width of the immovable finger is only about half the length of its free margin; whereas in *P. cavimanus* (♀) the carapace is shorter than 4th and 5th caudal segments, and the basal width of the immovable digit is about two-thirds the length of its free margin.

I at one time supposed this species to be the female of the Abyssinian *P. bellicosus* L. Koch, but judging by Kraepelin's recent diagnosis of the latter species (Das Tierr., Scorpiones, p. 121, 1899), *P. militaris* certainly differs in having the superior caudal keels denticulated, the hand finely punctulate above and below, and the last abdominal sternite scarcely visibly crested.

Synopsis of the Somali Species of Pandinus.

a. Median eyes always some distance behind middle of carapace; tarsi more numerously spined, the lobes with 3–4 spines, total number on lower side of tarsi 9 behind, 6 in front.

- *a*¹. Tarsal lobes with 4 spines, a strong spine being on the tip of the lobe; humerus of chela furnished below with two short rows of denticles.......................... *meidensis.*
- *b*¹. Tarsal lobe with 3 strong spines, the spine on the tip smaller and usually filiform distally; humerus of chela smooth below.
  - *a*². Ornamentation of hand consisting of conical tubercles; inner margin of hand distinctly tubercular and denticulate from base of finger to carpal articulation, width of hand greater than length of carapace; pectinal teeth 18–21 .... *smithi.*
  - *b*². Ornamentation of hand consisting of low rounded or irregular shaped, often anastomosing tubercles; lobe of hand with smooth posterior edge; length of carapace exceeding width of hand; pectinal teeth 15–18 .... *philipsi.*

b. Median eyes in middle of carapace, rarely a little behind the middle; total number of spines on tarsi 5 behind, 3 in front, 2 only being situated on each lobe, the tip of which is furnished with bristles.

- *a*³. Lower surface of all the caudal segments and the middle of at least the last abdominal sternite closely granular and not keeled.
  - *a*⁴. Upper surface of hand from inner edge to crest of underhand uniformly covered with coarse granules which do not anastomose; upper crest of brachium distinctly granular .... *colei.*
  - *b*⁴. Upperside of hand coarsely granular only above crest of underhand, the rest of its upperside either almost smooth or ornamented with low rounded tubercles which run into ridges; upper crest of brachium quite smooth.
    - *a*⁵. Upperside of hand covered with ornamentation of low, more or less anastomosing tubercles; its lower surface distinctly granular; hand larger, carapace equal to length of underhand + one-third of movable digit, and only as long as the hand from the posterior edge of the lobe to the base of the immovable finger; immovable finger not twice as long as its basal width .... *peeli.*
    - *b*⁵. Upperside of hand smooth, at most ornamented with a network of low ridges, lower side very sparsely granular; hand smaller, carapace as long as underhand + half the movable finger, and as the hand measured from the posterior edge of the lobe + half the immovable finger; immovable finger twice as long as its basal width. *hawkeri.*

b^3. Last abdominal sternite and lower side of 1st and 2nd caudal segments, and usually also of 3rd, smooth; caudal segments 1–3 keeled below.

a^6. Lower surface of 4th caudal segment coarsely but sparsely granular, the median keels obsolete, the lateral keels strongly denticulate; superior and superior-lateral crests of tail smooth; protarsal segment of 1st and 2nd legs with a single external apical spine .... *pugilator.*

b^6. Lower surface of 4th caudal segment not uniformly and coarsely granular, furnished with four normal, subequally strong keels; superior and superior-lateral crests of tail denticulated; protarsi of 1st and 2nd legs with at least two external spines...... *militaris.*

EXPLANATION OF THE PLATES.

Plate I.

Lepidoptera, Coleoptera, &c., from Somaliland.

Fig. 1. *Pseudophia oppia*, p. 18.
2. *Chilena sabrina*, p. 20.
3. *Cerocala munda*, p. 19.
4. *Acræa mirabilis*, p. 11.
5. *Belenois peeli*, ♂, p. 15.
6. ,, ,, ♀, p. 15.
7. *Pseudophia lineata*, p. 19.
8. *Pangonia tricolor*, p. 7.

Fig. 9. *Genecerus nebulosus*, p. 26.
10. *Psiloptera somalica*, p. 25.
11. *Agrypnus longicornis*, p. 26.
12. *Sepidium magnum*, p. 29.
13. *Rhytidonota robusta*, p. 28.
14. *Sepidium bilobatum*, p. 30.
15. *Julodis laticollis*, p. 25.
16. *Trox expansus*, p. 22.

Plate II.

Orthoptera from Somaliland.

Fig. 1. *Rhegmatopoda peeli*, p. 44. Left elytron. ♂.
2. *Otiaphysa angustipennis*, p. 43. Left elytron. ♀.
3. *Sauracris lacerta*, ♂, p. 41.
4. *Charieis peeli*, ♀, p. 37. (Antennæ and apex of abdomen missing.)
5. *Milititsa somaliensis*, p. 43. Right elytron. ♀.
6. *Burria longixipha*, ♀, p. 38.
7. *Milititsa somaliensis*, p. 43. Head and pronotum.

Plate III.

Ticks from Somaliland.

Fig. 1. *Rhipicephalus marmoreus*, p. 50. ♂. Dorsal view. ×11 times linear.
1 *a*. ,, ,, Ventral view.
1 *b*. ,, ,, Capitulum and mouth-parts from below.
1 *c*. ,, ,, Coxæ of 1st and 2nd legs.
1 *d*. ,, ,, Stigma, adanal plate, and anus of left side.
2. *Rhipicephalus armatus*, p. 50. ♂. Dorsal view. ×11 times linear.
2 *a*. ,, ,, Ventral view.
2 *b*. ,, ,, Capitulum and mouth-parts from below.
2 *c*. ,, ,, Coxa and trochanter of 1st leg.
2 *d*. ,, ,, Adanal plate of right side.
2 *e*. ,, ,, Lateral view of posterior end of abdomen showing adanal plate, spike above it, and stigma.
2 *f*. ,, ,, ♀. Dorsal view.

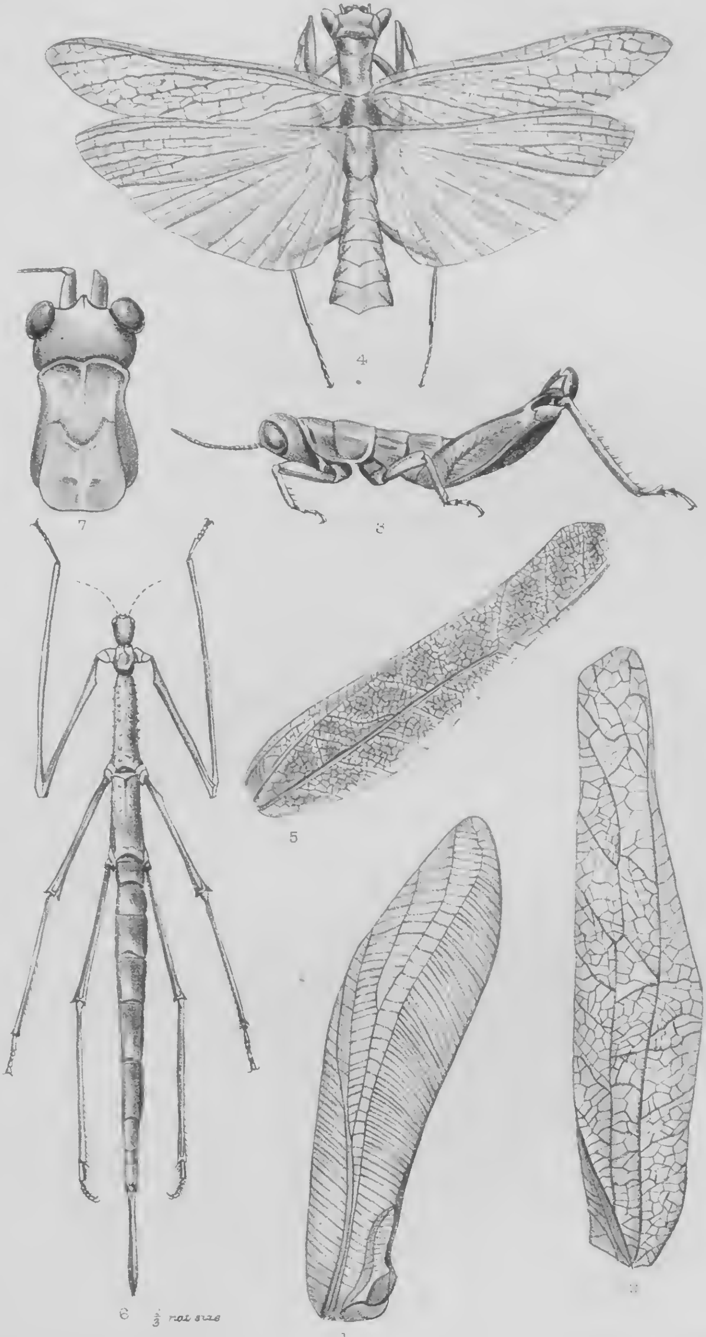
Plate IV.

Scorpions from Somaliland.

Fig. 1. *Pandinus pugilator*, p. 52. Nat. size.
1 *a*. ,, ,, Underside of tail.
2. *Pandinus peeli*, p. 53. Underside of tail.
3. *Buthus calviceps*, p. 54. Carapace.
3 *a*. ,, ,, Underside of 3rd, 4th, and 5th caudal segments.
3 *b*. ,, ,, Chela.

W. Purkiss del. et lith. West, Newman chr.

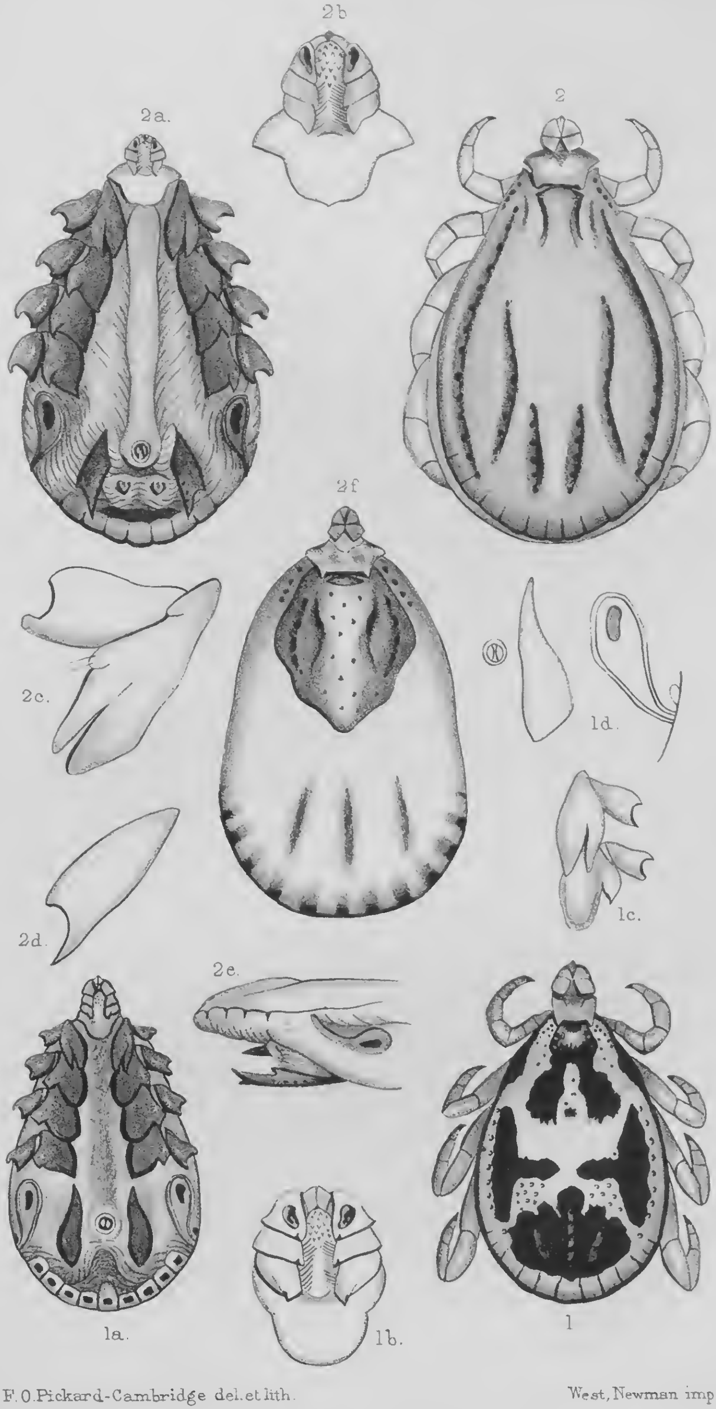
LEPIDOPTERA, COLEOPTERA, ETC. FROM SOMALI-LAND.



E.H.J. Schuster del.
F.O. Pickard-Cambridge lith.

West, Newman imp.

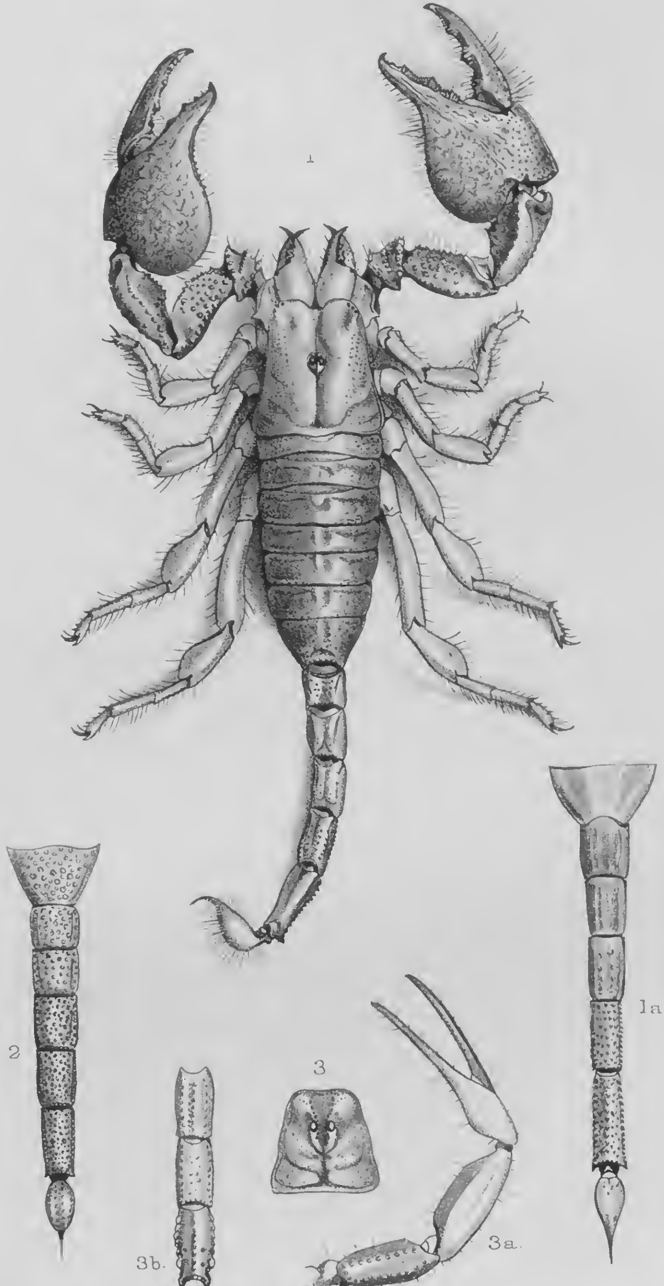
ORTHOPTERA FROM SOMALI-LAND.



F. O. Pickard-Cambridge del. et lith.

West, Newman imp.

TICKS FROM SOMALI-LAND.



F. O. Pickard-Cambridge del. et lith.

West, Newman imp.

SCORPIONS FROM SOMALI-LAND.

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On the British Orthoptera in the Hope Museum, Oxford.

By MALCOLM BURR, F.Z.S., F.E.S.

In the Hope collection, in the University Museum, at Oxford, there are a number of old specimens of considerable interest, as many are labelled in the handwriting of the late Professor Westwood, and some in the handwriting of Stephens. Professor Poulton has been kind enough to permit me to examine and rearrange them. The following notes on some of the older specimens may be of interest.

FORFICULARIA.—*Labidura riparia*, Pall.—One ♂, two ♀. "England." No further information on the labels. They are very probably some of the original specimens taken near Christchurch. *Anisolabis maritima*, Bon.—"Northumberland. G. Wailes. 1857, end of September." These are evidently not some of the original examples taken by Bold at South Shields, but those captured a few years later by George Wailes, when he took a number of specimens for his careful observations of the development of the antennæ and abdominal segments, recorded by him in the *Zoologist*, vol. xvi., p. 5895, in a paper that has to a large extent been overlooked, in spite of its great interest. The insect was taken in heaps of ballast emptied by ships returning from abroad, and it is practically certain that it was an importation. It was first captured in 1856, and was still to be found in 1860. It is unknown whether the species still exists there. *Labia minor*, L.—Six ♂, ten ♀. "Snowdon." *Forficula auricularia*, L.—Numerous examples. Two are labelled "*borealis*" in what I believe to be Stephens' handwriting; these are what I have always regarded as the variety *forcipata*. The difference between the two is merely a matter of the comparative length of the forceps. *F. lesnei*, Fin.—One ♀. "Kingstone," an old specimen. *Apterygida albipennis*, Meg.—One pair, old, and in bad condition. There is no locality attached, but the specimens are probably some of the originals taken at Ashford by Westwood. In his handwriting they are labelled "*F. centralis*, Westw., MS."

BLATTODEA.—*Ectobia lapponica*, L.—Ten ♂. "Sunning Hill, Berks." *E. livida*, Fabr.—"Rudd. N. F." This species has been previously recorded from the New Forest. *E. panzeri*, Steph.—Several examples. Two males labelled "J. C. Dale, 1865." One specimen, a male, is labelled "*Blatta nigripes*, Mus. Steph., in *Notes on habits*, B. G. C.," but it is too pale in colour to be the true form *nigripes*, and does not agree with Stephens' own description. It is the ordinary typical form. There are several specimens considerably darker in colour, approaching more nearly to the true *nigripes*. One dark specimen is labelled "Rev. W. Kirby, *lapponica*." There is one ♀ with ootheca labelled "Black Gang Chine." *Phyllodromia germanica*, L.—This species is usually considered to have been introduced into England by the soldiers returning from the Crimea, but we have distinct evidence here that it was numerous in parts of England before that date. There are several old specimens, one of which is labelled "Infesting the kitchens of houses at Kildare, Ireland, living behind

the skirting and abounding in the crevices of the kitchen table, destroying all kinds of paper and in many ways very troublesome, March 1852," and there is another specimen labelled in the same handwriting, "Mr. Gray Dudley; taken by him in his garden at the foot of Castle Hill." Reports of this species taken out of doors are rare. It occurs in a wild state in woods in Prussia and Russia, so there is no reason why it should not become settled wild in this country, as it has become firmly established in a domesticated condition. *Blatta orientalis*, L.—Several specimens unlabelled; one ♀ nymph "under bark of tree, 10ft. up, K. G." (?=Kew Gardens). It is rarely that this species is taken out of doors, for it seldom leaves the warm kitchens and hot corners that it loves. It would probably be unable to exist in the natural state in this country. There is one crushed and mutilated nymph, mounted on card with the label "Larva of a *Blatta*, sent by Mr. Backhouse from Gateshead, as a flea, and exhibited by J. O. W. at Ent. Soc. as *Pulex imperator*." This is the original type of Westwood's famous mistake. He exhibited this specimen at the Entomological Society (*Proc. Ent. Soc.*, 2nd series, iv., p. 70) in 1857, as a new species of flea, twenty times the size of the largest flea hitherto known! He corrected his mistake in the following year (*op. cit.*, v., p. 60). There is also a broken ootheca with the label "Egg-pouch of *B. orientalis?* Mr. W. Baird in acct. amongst ent. scraps. For the parasitic *Chalcididae* bred see them among *Chalcididae*." I have carefully searched through the drawers of the British *Chalcididae* and have been through Walker's *Monographia Chalciditum* but cannot find the specimens referred to.

Acridiodea.—*Mecostethus grossus*, L.—Five ♂ and three ♀. Without locality, labelled "*Locusta flavipes*." *Stenobothrus lineatus*, *S. viridulus*, *S. rufipes*.—Several specimens with no interesting labels. *S. bicolor*, Charp.—Many specimens without labels. One ♂ labelled "*crucigera*," and another ♂ "Isle of Purbeck, 1830. *L. rubicunda*." This is apparently the pink form known as *purpurascens*, Fieb. The name *rubicunda* has usually been referred to *S. viridulus*, of which a reddish form is sometimes taken. *S. parallelus*, Zett.—Several nymphs, and one empty nymph-skin, "Blenheim Park, 1832." *Gomphocerus sibiricus*, L.—One ♂ unlabelled, which is most probably Stephens' type, said to have been taken at Netley. *G. rufus*, L.—One ♂ unlabelled. *G. maculatus*, Thunb.—One ♂ "Devil's Ditch, Newmarket Heath, July 2nd, 1833. J. C. Dale." *Pachytylus migratorius*, L.—There are four specimens of undoubted *migratorius*, showing that this species has really occurred so far west as this country. One male is unlabelled, another "Littlehampton, Sussex, 1846, J. O. W." One ♀ "alive near Oxford, J. O. W." and a second ♀ "Ct. alive near Chepstow, September 16th, 1857." [There are no specimens of *P. danicus*, L.]. *Schistocerca peregrina*, Oliv.—Two specimens, one labelled "F. Bond, Esq., near Falmouth, a number of specimens near Plymouth," the other "Cornwall, F. Bond, Esq., 1870." A good many examples of this locust were taken in Britain in 1869, but I do not think any have been recorded for the following year. *Tettix subulatus*, L.—"Cambridge." Some are labelled "*bipunctatus*." *T. bipunctatus*, L.—About 30 specimens without labels.

Locustodea.—*Leptophyes punctatissima*, Bosc.—A number of unlabelled specimens. One female "caught October 1st, Coombe

1806, *clypeata*, Pz., Mr. Neale." One ♂, two ♀, "Miss Badcock, on a pear tree," another "*Ephippigera virescens*, Steph., *Ill.*, vi., 16, viii., 33." *Ephippigera virescens*, Steph., is known to be a synonym for *L. punctatissima*, but "*clypeata*, Panz.," is usually regarded as a synonym of *Thamnotrizon cinereus*, L. *Meconema varium*, Fabr.—One male "Sept. 16th, 1833, Foxley Wood, Norfolk," another "Taken in second week in November, '66, Mr. Briggs, St. John's Coll." This species is one of our latest Orthoptera, and may be taken well into the winter. One female, "Miss Badcock, on a pear tree." *Xiphidium dorsale*, Latr. —One male labelled "*Acrida fusca*," and a male "Norfolk, August 1st, *A. fusca*, Pz.," also four ♂, seven ♀ and two nymphs, all labelled "*fuscum*." Stephens obviously confused *X. dorsale* with *X. fuscum*, a very distinct species, which is far more common and widely distributed on the continent than *X. dorsale*. *Locusta viridissima*, L.—One male "Parks, Oxford, 1848;" several unlabelled specimens. *Thamnotrizon cinereus*, L.—One male "*D. apterus*," one ♀ "near Croydon," one ♀ "*ephippiger*" and four ♂ and four ♀ unlabelled. *Platycleis grisea*, Fabr.—Several specimens without labels, one nymph queried "*viridissima*, ex Museo D. Hill." *P. brachyptera*, L.—One ♂ labelled "*brachyptera*" and one "*kirbii*" also a male labelled "*clypeatus*" and several nymphs "*kirbii*." *Decticus verrucivorus*, L.—A male "*bingleii*, Rev. D. Bingley," probably one of Curtis' types, but of the green form, also one female "*verrucivorus*."

Gryllodea.—*Nemobius sylvestris*, Fabr.—Several specimens of both sexes, unlabelled. *Gryllus campestris*, L.—One male "Weaver, N. F." and several specimens without labels, including one of the very rare variety with fully developed wings, projecting well beyond the elytra. [There is also a specimen with wings projecting far beyond the apex of the abdomen, which I refer with some doubt to *G. bimaculatus*, de Geer, a meridional species. It may be an extreme form of *G. campestris*, or may have been accidentally introduced.] *G. domesticus*, several examples, unlabelled. *Gryllotalpa gryllotalpa*, L.—Five ♂, four ♀, unlabelled.

THE METHODS OF SETTING AND LABELLING LEPIDOPTERA FOR MUSEUMS.

By E. B. POULTON, M.A., F.R.S., Hope Professor of Zoology in the University of Oxford.

UNTIL quite recent years the method of setting butterflies and moths adopted in this country differed very widely from that which prevailed and still prevails on the Continent. Furthermore, the continental method has been uniform, while the British has varied in many directions, according to the taste of different distinguished collectors, each of whom may be said to have founded a fashion which endured for a time and over a more or less limited area.

In continental setting very long ($1\frac{1}{2}$ inches or more, and inconveniently flexible for use with a cork lining to the drawer) foreign pins are used; the insect being pierced so that the pin is as nearly as possible upright. The insect is raised on the pin so that a length of only from $\frac{3}{32}$ to $\frac{1}{4}$ of an inch projects above the dorsal surface of the thorax. The wings are extended on flat boards, the object being to render them as horizontal as possible. The margin of the fore wing which overlaps the hind wing (inner margin) is placed at a right angle to the long axis of the body, and therefore in a line with the corresponding part of the opposite fore wing. This arrangement involves, in the great majority of Lepidoptera, a strained or unnatural appearance, owing to the fore wing being drawn so far forward—an effect which is sometimes increased by drawing

the hind wings backward so as to leave a considerable gap between them and the fore wings.

It has been already stated that there is no one British method, but a great variety, differing widely from each other and from the continental. The pins used are of British make and superior in stiffness to those supplied by the continental makers. There is no attempt at uniformity in length, but the size of the pin is regulated by that of the insect. The insect is pierced so that the pin slopes forward, but there is no uniform or standard slope; and, indeed, such a standard would be far more difficult to attain than under the continental method, in which the upright pin is required. Even the longest pins ($1\frac{3}{8}$ inches) used are inferior in length to the continental pins. In the older collections set in England the insect was placed very low on the pin, so low in fact that the edges of the wings (hind margins), which were made to slope downwards, rested on the paper lining of the cabinet drawer. The obvious danger and injury involved in this position—the tendency to curl up—the ready accumulation of dust—the convenient access afforded to mites, etc.—the want of a space on the pin below the insect for the attachment of labels—gradually caused its abandonment; so that, in most modern English collections, the insects are fixed higher on the pin; but here again there is no standard, some collectors being satisfied if the insect be just clear of the bottom of the drawer, others raising it until only from $\frac{3}{32}$ to $\frac{1}{4}$ inch of pin projects above it, as in the continental method, others again adopting an intermediate position. The wings are set less forward than in the latter method, and care is exercised to preserve the natural amount of overlap of the fore over the hind wing. Instead of the flat setting the aim has been to make the wings slope downwards away from the body of the insect, and to increase the slight, natural curvature of the insect's wings. This is usually accomplished by curved setting-boards, but it has been brought about by means of cardboard slips placed *below* the central part of the wings, together with other slips *above* their outer part, the elasticity

of the wings keeping them in place. It has even been suggested that a curvature from back to front in addition to that from side to side would be peculiarly elegant, and collectors have been advised to make setting-boards out of portions cut from a sphere.

Apart from the relative advantages and disadvantages offered by these methods, the fact of the difference is much to be regretted. One of the most serious difficulties which have been brought about is the want of uniformity in the depth of the drawers of British and continental cabinets; and here, too, the want of a standard has produced inconvenient results within the limits of this country—the British cabinets varying from an effective depth from glass to paper of $1\frac{1}{8}$ inches to one of $1\frac{7}{32}$ inches, as against a depth of $1\frac{1}{2}$ inches in the continental drawers. This is, of course, excessively inconvenient when any large exchange of specimens takes place. In fact, it is not too much to say that the uniformity of the continental method would render its adoption expedient even if it were less suitable in other respects. But a careful comparison of all the various points will show that in almost all points it is superior to the English method. I will take the various points separately.

Choice of Pin.—The largest English pin (No. 16 or No. 11, with a length of $1\frac{3}{8}$ inches) is stiffer and more convenient than the continental article, and is sufficiently long to permit the advantages mentioned in the paragraph below. All insects, large and small, should be mounted so that they are at an equal distance from the glass.

Height of Insect on the Pin.—The immense advantages of a high position have been already mentioned: furthermore, it may be added that it is of advantage to bring the insect near to the glass, so that it can be examined with a lens without removing the cover. The high position also enables the observer to read two or three labels placed at different heights on the pin below the insect without disturbing them or the insect, and even without removing the cover of the

drawer. In these days of careful cataloguing, and full and accurate data, this abundant space for small labels is of the utmost importance. It should be noted that the proximity of the insects to the glass necessitates care in the removal of the covers, because of the injury to the wings which is apt to be caused by a sudden rush of air.

Direction of the Pin.—The upright position has the great advantage that it favours uniformity, which, on the other hand, is very difficult to secure over a wide area with the sloping position. The latter method, furthermore, tends to hide the labels on the pin, inasmuch as it brings them further under the body of the insect.

Plane of the Wings.—The flat position also favours uniformity, whereas the slope always tends to vary according to the taste of the collector. Another, and perhaps the chief, advantage is that the flat wings being at right angles to the line of vision are more clearly and distinctly seen. To see the sloping wings perfectly the insect must be turned first to one side and then to the other, and *both* sides cannot be seen perfectly at the same time. The flat continental boards do not, as a rule, produce perfect flatness because the wings are naturally curved a little, and this requires special correction. Mr. H. J. Elwes has devised boards, now much used in this country, which are curved slightly in the opposite direction, viz., upwards, and these are very effective in producing the desired flatness. The wings are usually held in place by strips of engineers' tracing cloth secured by the ordinary milliners' steel, glass-headed pins, which can be easily driven into soft wood.

Forward direction of the Wings.—Here, too, the continental method of placing the inner margin of the fore wings at right angles to the body has the great advantage of uniformity, and when the setting is performed mechanically, with no knowledge of or interest in the insects themselves, it would probably be the most expedient system to adopt. If, however, the setter has something of the feeling of a naturalist and artist, far more pleasing results may be obtained by placing

the wings in as natural a position as is consistent with their proper display, the latter being, of course, the paramount consideration. Some judgment will be necessary in dealing with insects of which the habits are unknown. I think it may be assumed that the natural amount of overlap—easily distinguished by the characteristic texture and appearance of that part of the hind wings which is naturally concealed—should always be retained.

The feeling in favour of this or that form of setting, apart from the considerations of utility, is largely, if not entirely, a question of fashion. As a boy I looked on the continental setting with horror; now the sight of the sloping wings in contact with the paper gives me a cold chill. It is probably the case that a very large number of our collectors are still strongly in favour of some form of the English method. To these I would urge the advantage of uniformity, and would point out that the method they still follow is disappearing with all possible speed. The British Museum, the Godman-Salvin Collection, Mr. Herbert Druce's Collection, and the Hope Collection are all being rapidly transformed in the direction I have indicated. The method was first shown on a large scale in this country in the fine collection of Mr. Elwes. Whatever our preferences may be, the question is being rapidly settled on grounds of expediency, and the sooner the change is effected the better it will be for everybody.

Before concluding I must say a few words about labelling. The most important fact is, of course, the locality, and this should be precise and exact: next in importance is the date of capture; next the name of captor; then the date of presentation and the name of donor. Of some interest for future workers is a statement as to the authorship of the manuscript label. As regards locality, at Oxford we make a point of printing the most important word first and in capitals; then follows the more minute locality and the height above the sea, if attainable. Examples of the labels

of specimens presented to the Hope Collection in 1897 are printed below:—

MEXICO
Pacific Slope,
Zavaleta Canon,
12 m. S.W. Oaxaca.
Capt. Nov '96-May,
1897 (dry season).
Presented 1897 by
Osbert H. Howarth.

HUDSON STRAIT,
P. of Wales Sound,
Lat. 62° 35' N.
Long. 77° 22 W.
Capt. July 23, 1886,
and pres. 1897 by
F F Payne.

CHICAGO, ILL.,
59th Street,
Waste Land by
I.C.R. Bridge.
Capt. July 21, '97,
and pres. 1897 by
E. B. Poulton.

NR. DURBAN, NATAL,
Malvern, 800 feet.
Capt March 30, 1897,
and pres. 1897 by
Guy A. K Marshall,
m.s. by G. A. K. M

In the much rarer cases in which notes of experiments or of natural history observations accompany the specimens, these are incorporated in an epigrammatic form in the label. Examples are given below:—

NR. DURBAN, NATAL,
Malvern, Umbilo R.
(sea level).
One of 12 Euralia
mima and wahlbergi
at rest on fern
3-4 p m., June 28, '97.
Capt. and pres. 1897
by G A K Marshall.
m.s. by G. A. K. M.

NR. DURBAN, NATAL,
Malvern, 800 feet.
Pupa in moisture
6 d. 10 h. Imago,
bred April 10, 1897,
and pres. 1897 by
Guy A K. Marshall.
m.s. by G. A. K. M

As regards date of capture the importance of the day of the month is at once seen in relation to the recent work upon seasonal forms and as giving a solid fact in the natural history of the species. Many excellent collectors neglect the date altogether. This is a serious error; for the study of the gradual changes in the distribution of forms will demand these very data from the specimens now being added to our Museums. To take a concrete case. *Hypolimnas misippus* has of late years invaded America, and the dates of its arrival and gradual spread are of very great interest. There is a Godman-Salvin specimen in the British Museum captured by Belt in the Montes Aureos, Maranhão, Brazil; but without a date. In this case, no doubt, the date can be fixed approximately by indirect means, although I have not as yet been able to ascertain it; but in many other cases it cannot be recovered. What a splendid history of the gradual spread of *Anosia plexippus* from its home in North America could be deciphered from our great collections if only the collectors had troubled to put dates on their captures. When labels are printed it is almost as easy to print two or three as one only. It is of great advantage to pin a second label *beside* the specimen where it can be read with the greatest ease, while

a third may be found useful for cataloguing. Diamond type will be found the most satisfactory for this purpose, while a small and simple press, which permits easy and rapid alteration of type, is the most convenient.

MR. PLATNAUER asked if anything could be done to the pin to render it more difficult for the predaceous intruder to climb it. He also questioned the wisdom of putting labels, and especially the original or collector's label, on the pin under the insect. Not only did it make the collection more unsightly, but it exposed the label to the risk of sharing the fate of the specimen. He would suggest that the specimen bear a number only, and that this number refer to a catalogue which could contain full references, and into which the original label could be pasted. In this case, everything would not be lost at one blow; even if the specimen were destroyed, the reference would remain.

DR. PETRIE asked whether labels or pins could not be treated with protective substances such as white arsenic or corrosive sublimate and glycerine.

MR. POULTON said that the labels under the pin formed an excellent barrier against intruders. The use of strong antiseptic or protective substances, such as arsenic and corrosive sublimate, was objectionable on account of their tendency to make the pin brittle. The question of pins was important enough to constitute a separate subject for consideration; he himself knew of no satisfactory substitute for the pins ordinarily used by entomologists, although some authorities favoured platinum, some silver, and some steel pins. The best way to preserve Lepidoptera was to keep the drawers containing them thoroughly disinfected with a good antiseptic. Nothing was better adapted for this purpose than naphthalene. As to putting labels into a catalogue, the objection seemed to him that this exposed the collection to the risk of total loss of all references by one mishap. If the catalogue were lost or destroyed, *all* information with regard to the specimens would be gone, whereas, with separate labels on the specimens, there was not nearly the same chance of an extensive loss. He instanced the Burchell collection of South American Lepidoptera which was almost useless in consequence of the loss of its catalogue. [Since the above was written this catalogue has been recovered, but it is impossible at present to decide whether it is complete.—E. B. P., 1898.]

June, 1898.

Report of the Hope Professor of Zoology.

The year 1897 was marked by very large accessions to the Hope Collections, chiefly of specimens obtained from Canada and some of the adjacent States (Illinois and Wisconsin). The British Collections were also very largely increased. Mr. G. A. K. Marshall's gift of South African butterflies, described in detail below, must also be specially mentioned.

Much work has been done in labelling the Godman-Salvin specimens and classifying the existing manuscript labels for printing. The W. W. Saunders Collection of *Sphingidae* have received printed labels giving the geographical data and the historical account of the specimens. An example of the form which has been adopted is reproduced below.

NEW ZEALAND
Cape Campbell
Ex Coll. (1830–73)
W. W. Saunders.
Presented 1873 by
Mrs. F. W. Hope.
ms. locality by
W. W. S.

Similar labels have been added to a part of some other groups and will eventually be extended to the whole of the historic collection of moths which the University owes to the generosity of Mrs. F. W. Hope.

In March, Mr. H. R. Smith, the Junior Assistant, left this country for Canada. Before leaving he presented a large number of insects for the British Collections, and he has since sent a number captured in Canada.

After waiting a few months this place was filled by the appointment of Mr. A. H. Hamm of Reading. Three-fourths of his time is devoted to the Hope Department, the remaining fourth being occupied by the Delegates in printing for the Museum. His experience as a printer has proved of great

value in the immense amount of labelling required by the Department.

At the close of the year the thorough revision of the Hope Library was commenced and has occupied Mr. Holland's time ever since.

The Danaine butterflies, with the exception of the *Ithomiinae* (*Neotropinae*), have been finally arranged by Mr. Holland in two of the new cabinets. In this group, so far as it is at present arranged, the Godman-Salvin specimens are incorporated, and the whole re-set according to modern principles, with coloured labels to show the geographical distribution of the species and genera, and with printed locality labels to a large proportion of the specimens, constituting an extremely instructive and valuable Collection. It is much to be regretted that the imperative necessity for classifying the Library has for a time interrupted the progress of this work.

In the course of this arrangement and in the preliminary work upon other groups preparatory to their final arrangement, it has been necessary frequently to consult the Insect Department of the National Collection and the Godman-Salvin Collection. In this work the greatest courtesy has been shown, and much kind help afforded.

The Department has, as in previous years, received much invaluable help in the determination and arrangement of the specimens.

Mr. M. Jacoby has continued his kind assistance in working out the large Collection of Phytophaga (Coleoptera). Dr. Dixey has worked at the *Pierinae* preparatory to their final arrangement. Col. Swinhoe has continued and has nearly completed the arrangement of the Oriental Heterocera; Mr. Arthur Sidgwick and Mr. Pogson Smith the arrangement of the British Heterocera; the Macro-Lepidoptera and the Deltoids being now finished and contained in about 100 drawers in two cabinets. Mr. Malcolm Burr has done much work upon the Collections of *Forficulidae* and *Acridiidae*. Miss Cecil Vernon Harcourt has prepared the Collection of British Aculeate Hymenoptera for final arrangement, printed labels for the specimens, and has begun the arrangement.

Mr. G. C. Champion has worked out the *Tingitidae* (Rhynchota Heteroptera) in the Department and described one new genus and three species (Trans. Ent. Soc. Lond. 1898, p. 55).

Several distinguished entomologists have visited the Hope Collection in the course of the year, and have given much needed advice and assistance as regards the groups which they have specially studied. Col. Bingham made a rapid survey of the very large general Collection of Aculeate Hymenoptera, Mr. Edward Saunders of the Palaearctic Aculeate Hymenoptera. Mr. Alexander Fry gave valuable information about the Miers Collection. Dr. F. Moore, after visiting the Department, worked through the Eastern species of *Neptis* and allied genera of butterflies. Mr. R. H. F. Rippon examined the butterflies of the genus *Ornithoptera*, and has since worked out the more obscure forms. Mr. W. F. Kirby identified many types of Homoptera.

The Council of the Entomological Society were invited to visit Oxford, July 3–5. The President, Mr. Roland Trimen, F.R.S., the Treasurer, Mr. R. McLachlan, F.R.S., the Secretary, Mr. W. F. H. Blandford, Professor Meldola, F.R.S., Mr. O. Salvin, F.R.S., Sir George F. Hampson, and Mr. M. Jacoby were present, while Mr. F. D. Godman, F.R.S., and Mr. Herbert Druce also joined the members of Council and the Oxford entomologists. Many friends of the Department kindly assisted in entertaining our visitors. The Hope Collection has greatly benefited by the experience of these distinguished authorities in so many groups of insects.

The state of the fund for the purchase of new cabinets which are so greatly needed by the Department was shown in the Report of 1896. It has now been raised to over £400, by £10 kindly subscribed by the Warden of All Souls.

New cabinets containing 200 drawers were delivered in November, and another equal consignment has since arrived (March 1898). These 400 drawers have been excellently made by O. E. Janson and Son, and are in every way satisfactory. The fund is now exhausted, but it is much to be hoped that £200 for another consignment may be raised at least six months before the arrangement of these

400 drawers is complete; for it has been found that *at least* this period must elapse between the order and delivery.

The first volume of the Hope Reports appeared on June 14. This volume contains copies of the various original memoirs which were written in connexion with the Hope Department between June 1893 and June 1897. During these four years much time and attention has been devoted to securing increased space and many necessary conveniences for work in the Department; so that it is confidently to be hoped that the succeeding volumes will appear at much shorter intervals. Indeed the materials for Volume II are already accumulating rapidly. The volume has been or will be distributed to Hope Curators, Delegates of the Museum, College and University Libraries, and to the majority of those interested in the progress of Science in Oxford. Outside Oxford they are sent to the chief Scientific Libraries of England, the Continent and America.

Volume I contains 16 memoirs by W. Garstang, M.A., W. Schaus, F.Z.S., F. A. Dixey, M.A., M.D., and Professor Poulton, M.A., F.R.S.

Additions to the Collection.

Fifty-six specimens of butterflies, captured April 5, 1896, near Durban, Natal, by D. Chaplin, Esq., were presented by F. D. Godman, Esq., and O. Salvin, Esq. Many of these are of especial value in providing material for the separate series illustrating Mimicry and Common Warning Colours.

A Dipterous insect from the Isle of Wight was presented by B. S. Ogle, Esq.

A very valuable set of 13 *Forficulidae* from Lombok, W. Java, and S. Celebes, and 3 Orthoptera from Surinam and W. Java, was presented by Malcolm Burr, Esq. (New College, Oxford), together with 14 Neuroptera captured by him at Esher.

A fine set of larvae of *Vanessa urticae*, var. *ichnusa*, was brought from Corsica by H. C. Playne, Esq., M.A. (University College), and bred in the Department together with one

Vanessa atalanta. Of the former 13 selected specimens were added to the Collection. Furthermore 27 specimens of insects of various orders from N.W. Finland were presented by H. C. Playne, Esq., and A. F. R. Wollaston, Esq.

Thirty-one specimens of Lepidoptera from the Italian Alps were presented by H. M. Wallis, Esq.

Two Rhopalocera from the shores of Lake Erie, Ontario, were presented by Dr. G. S. Ryerson of Toronto.

A moth and a beetle, bearing a close resemblance to each other, both captured in June 1897, by H. G. Hubbard, Esq., in the Chiricahua Mountains, Arizona, were presented by Dr. L. O. Howard of Washington. These will prove a valuable addition to the series on Mimicry, &c.

Two Rhopalocera from Corsica, and 8 from Civita Vecchia, were presented by A. B. Trevor-Battye, Esq.

A large and valuable collection of 215 Rhopalocera captured in Trinidad about 1874, was presented by Prof. R. Meldola, F.R.S. The collection includes a specimen of *Hypolimnas misippus*, thus proving that this oriental species, now established in many of the W. Indian Islands and in parts of tropical America, had reached Trinidad by or before 1874. Several specimens from this Collection will be included in the separate series on Mimicry.

A collection of 119 specimens of Lepidoptera from Demerara was presented by A. Waterfield, Esq. In this collection the same species (*H. misippus*) is included, and Mr. Waterfield informs me that he has observed its gradual increase during recent years.

Nineteen Lepidoptera from Tasmania were presented by M. Jacoby, Esq.

A specimen of *Limnas chrysippus* from Greece was presented by Rev. G. D. Allen, B.A.

Eight specimens of 2 species of *Forficulidae*, new to Britain, from Queenborough, Kent, together with a rare Coleopterous insect from Chatham, were presented by J. J. Walker, Esq., R.N.

Fourteen Lepidoptera from Mercedes, B.A., Argentina, were presented by Rev. F. D. Tubbs.

A set of 5 *Araschnia prorsa-levana*, bred from European pupae, was presented by Dr. F. A. Dixey.

A very fine set of 78 Lepidoptera from the neighbourhood of Brisbane, 31 from Ecuador, and 1 from Colombia, was presented by G. C. Griffiths, Esq.

A fine set of 80 Lepidoptera and 1 Coleopteron from the neighbourhood of Oaxaca City, Mexico (6,100 ft.), was presented by Osbert H. Howarth, Esq.

Further invaluable additions to our series of African butterflies were made, as in last year, by Guy A. K. Marshall, Esq. The collection shows the same accurate labelling which renders it so especially valuable to us. The collection contains 416 Rhopalocera, 2 Heterocera, and 2 *Ichneumonidae* from various localities (all precisely recorded, and now copied on printed labels) in Natal; and 143 Rhopalocera from various localities in Mashonaland.

In addition to these important accessions, Mr. Marshall has presented several groups of the utmost interest and value for the series on Mimicry, &c. Some of these captures prove that the species which resemble each other in the same locality also occur at the same time of the year. Thus the Hope Collection has received 5 specimens of butterflies of the group which resembles *Amauris echeria*, all captured at Malvern, Natal, on March 6, 1897; 8 butterflies of the *Limnas chrysippus* type of pattern and colouring, captured at Malvern on the same date, and again 6 of this latter group on March 30. Also 5 specimens of butterflies and moths which appear to resemble one of the black and white species of *Amauris*, probably *A. ochlea*, captured at Malvern on March 27. Thirty-three other specimens in part illustrated the same principle, in part certain interesting observations on the habits of *Euralia mima* and *E. wahlbergi*, and in part formed the material of some important experiments on the effect (on the perfect insect) of dry heat and moisture upon the pupae of various species of butterflies. A detailed account of these experiments will be published shortly.

The absence of Professor Poulton in America, from the middle of July to the middle of September, caused an

immense accession of specimens captured by him and the friends who accompanied him, and also kindly presented by many naturalists who reside in Canada and the United States. The work thrown on the Department in setting, printing, and cataloguing, has consequently been so excessive that it has been found impossible to include a complete account of these and many other additions in the present Report. A brief account will now be given, to be followed next year by a complete description giving the numbers of specimens.

Professor Poulton's captures (of insects of nearly all orders) were chiefly made at Quebec, Montreal, Toronto, Chicago, Detroit, Niagara Falls, Hartland (Wisconsin), Rat Portage, Rush Lake, Regina, Lake Louise (Laggan), Glacier House (Selkirks), Vancouver City, and Victoria (Vancouver Island). Small numbers of captures were also made at a very large number of localities on the Canadian Pacific Railway.

Professor Meldola, F.R.S., also captured and presented a very large number of specimens from the Canadian localities.

In Chicago, Professor Wheeler and Professor Watasé captured many specimens for the Hope Department, and the former also presented some valuable specimens from his own collection for the series on Mimicry, &c. In Hartland, Professor Poulton was kindly helped by Dr. G. W. Peckham, who also presented specimens, chiefly of Aculeate Hymenoptera, he had previously captured.

At Victoria he received much kind assistance from Dr. E. Crompton (of Victoria), from E. A. Carew-Gibson, Esq. (of Victoria), from Dr. Kirker (of Esquimalt), and from Professor Fitzgerald, F.R.S. Furthermore a fine collection of insects, chiefly Lepidoptera, from the neighbourhood of Victoria was presented by the captors, Dr. E. Crompton and F. Crompton, Esq. These will be of the greatest value to the Hope Collection. A small set of insects from the neighbourhood of Victoria was presented by E. Baynes Reed, Esq., of Victoria, and another from Vancouver City, by C. A. Ellis, Esq., of Vancouver.

Valuable collections from Ottawa and from Virden (Mani-

toba), were made during the Summer and Autumn of the year by Miss M. G. Holmes and presented to the Department. The data accompanying the specimens were unusually full and precise. Mr. H. R. Smith has also sent a large collection from the neighbourhood of Russell, Manitoba.

A small but very valuable collection from the far north—Hudson's Strait—was presented by the captor, F. F. Payne, Esq., of Toronto. Miss E. C. Ramsay and W. Ramsay also presented many specimens captured by them in Montana, U. S. A., and at localities on the Canadian Pacific Railway.

Specimens from Canadian localities were also presented by E. H. Chapman, Esq., B.A. (Magdalen College).

From this preliminary list of presentations it will be seen that the North American insects of the Department have been very greatly augmented during 1897. This addition will be especially welcome, as the insect fauna of this interesting region is poorly represented in the University Collection, while the specimens we already possess are very poorly and insufficiently labelled. The large collection now added is especially strong in this respect.

The Professor also desires to acknowledge the kindly interest and sympathy which he everywhere received throughout the whole of his visit, in his efforts to add to the Hope Collection.

The extra strain thrown on the Department has also prevented the cataloguing of many other valuable accessions from other sources. These, too, will now be briefly mentioned, the full record being deferred till next year.

A small but very valuable collection of insects, made in Sokotra in the winter of 1896–7, by E. N. Bennett, Esq. (of Hertford College, Oxford), was presented by him. Although the insects are in poor condition they are of great interest, and include 2 new species of Rhopalocera, 1 of Orthoptera, and 4 of Arachnida, which have since been described.

Colonel Swinhoe has presented a very large number of Heterocera, many Rhopalocera, especially *Pierinae*, and also some specimens for the series on Mimicry, &c.

A valuable collection of insects of many orders captured

upon two visits to Somaliland by C. V. A. Peel, Esq., was presented by him. Several new species are probably included, which will be worked out as soon as possible. Mr. Peel also presented a few Rhopalocera from various localities.

A large collection of Lepidoptera from many localities has been presented by H. Druce, Esq. Many of these will be of the highest value to the Hope Collection.

A set of insects, chiefly Lepidoptera, from British Guiana, has been presented by Rev. O. Pickard-Cambridge, F.R.S.

Several European Rhopalocera and Coleoptera have been presented by Rev. G. D. Allen.

A set of Swiss Lepidoptera was presented by Mrs. Bassett.

A few Rhopalocera, especially needed by the Collection on account of their rarity or the localities at which they were captured, were presented by Mr. A. H. Hamm.

The British Collections have been greatly strengthened during the year by very large accessions, with excellent data, presented by Mr. W. Holland, Mr. H. R. Smith, and Mr. A. H. Hamm. The specimens are principally Lepidoptera, but other orders are also represented; the specimens were principally captured in the neighbourhood of Oxford and Reading.

Dr. F. A. Dixey presented a valuable set of insects of many orders captured by him at Morthoe, N. Devon. The data accompanying the specimens are excellent.

Miss Thoyts presented a valuable set of Aculeate Hymenoptera captured at Sulhampstead, Reading, the data being especially complete. British specimens of the same order were presented by Edward Saunders, Esq., from his collection.

The British Collections were also increased by specimens presented by Arthur Sidgwick, Esq. (Lepidoptera), Miss C. V. Butler (a specimen of the rare moth, *Drymonia chaonia*, captured near Oxford), Professor Poulton (chiefly Lepidoptera from Freshwater, Isle of Wight), and his son, Edward P. Poulton (two rare moths from St. Helen's, Isle of Wight).

A moderate number of specimens, chiefly intended for the

Series on Mimicry, &c., were purchased from Watkins and Doncaster.

In addition to the gifts fully recorded or briefly mentioned above, the Hope Department has received from Canon Tristram, F.R.S., a valuable set of 291 insects of many orders from Palestine. The history of the collection is remarkable. These insects, with others, occupied four drawers in the Department which were labelled Palestine. They probably reached Oxford about 30 years ago, but nothing was known of them except the statements in Professor Westwood's handwriting that all came from Palestine and that a part had been captured by the Rev. O. Pickard-Cambridge. There was also a label on one drawer with these words, "*Tineae* named by Stainton," and on another, "Oxford and Cambridge Exploration Fund. Hymenoptera to F. Smith." It was known that Professor Westwood was very careful of the insects and would never allow them to be placed in the general collection. Enquiry not only failed to ascertain the existence of an "Oxford and Cambridge Exploration Fund," but showed that these insects were certainly unconnected with any fund of the kind. A label from one of the *Tineina* was then sent to Lord Walsingham, who not only identified it as the handwriting of the late H. T. Stainton, but also as the label of a long-lost type described in "The Tineina of Syria and Asia Minor" (London, 1868). Lord Walsingham furthermore stated that all these *Tineina* had been given to him by Canon Tristram, and the Canon himself wrote in confirmation. The matter was brought before the Hope Curators and the Professor was authorized to forward the 56 specimens (36 species and 31 types and co-types) of *Tineina* to Lord Walsingham. This result did not encourage further researches into the history of the collection. Nevertheless Canon Tristram was written to about the remaining specimens, and he explained that Professor Westwood had borrowed the whole collection from him for the purposes of study. The specimens had been principally captured by Rev. O. Pickard-Cambridge, F.R.S., in 1865, but a large number by Canon Tristram

himself in 1863–4, and the whole collection was undoubtedly his property. He has now very kindly presented the whole of them to the Hope Department in which they have rested so long.

ADDITIONS TO THE HOPE LIBRARY.

The Smithsonian Institution (United States National Museum) presented their publications during the year, which dealt with the subjects of the Hope Department.

The Boston Society of Natural History and the Bombay Natural History Society presented their publications for the year.

The University of the State of New York presented three volumes of their Report, 48 (1, 2, and 3).

The Secretary of State for India in Council presented the four volumes on "The Moths of India" by Sir George F. Hampson.

The Director of the Royal Indian Marine presented two parts of "Illustrations of the Zoology of the Royal Indian Marine Surveying Steamer Investigator."

The Linacre Professor of Comparative Anatomy, Oxford, presented "The Linacre Reports," vol. ii.

"The Hope Reports," vol. i, was deposited in the Library.

The Radcliffe Librarian, Oxford, presented the Catalogue of Books added during 1896.

The Transactions of the Entomological Society, and the Transactions and Journal of the Linnean Society for the year 1897, were presented by Professor Poulton.

Canon W. W. Fowler presented the parts of his monograph in the Biologia Centrali-Americana (Rhynchota Homoptera, vol. ii), published during the year.

Copies of original papers were also presented by the following authors :—Dr. L. O. Howard, Sir George F. Hampson, Malcolm Burr, Esq., Hamilton Druce, Esq., F. T. Howard, Esq., and T. H. Thomas, Esq., Miss Eleanor A. Ormerod, Baron Osten Sacken, Herbert Druce, Esq., Rev. T. R. R. Stebbing, G. H. Carpenter, Esq., P. P. Calvert, Esq., and G. W.

Kirkaldy, Esq. Two plates of *Euplocinae* were presented by F. C. Moore, Esq.

An extremely valuable copy of W. J. Burchell's "Travels in the Interior of Southern Africa" (London, 1822), containing MS. notes and corrections by the author, was presented by J. P. Mansel Weale, Esq. The presence of the Burchell Collection in the Hope Department renders this gift especially welcome.

Several second-hand works of reference and original papers were purchased during the year, together with the Zoological Record, the parts of Barrett's "British Lepidoptera," the Ray Society volume for the year, and the parts of Rippon's "Icones Ornithopterarum."

EDWARD B. POULTON.

Report of the Hope Professor of Zoology.

The additions to the Hope Department made during the year 1898 are numerous and valuable, although they do not approach those of 1897. Mr. Guy A. K. Marshall's beautifully collected specimens from South Africa, accompanied by full and precise data, must be specially mentioned, as in previous years.

One of the principal labours of the year was a thorough revision of the Hope Library and comparison of the volumes with the (very incomplete) slip catalogue. The thousands of works which require cataloguing were rendered easily recognizable, while the numerous duplicate volumes and pamphlets were identified and separated. At this point the work was postponed owing to the needs of the Collection, but the completion of the catalogue at an early date is absolutely necessary for the assured safety and proper and convenient use of this valuable library. It is much to be hoped that some means may be found whereby this work can be done without encroaching further upon the amount of time and work devoted to the Collections. Mr. W. Holland commenced this revision in 1897, and it occupied almost the whole of his time for the first half of 1898. Mr. R. McLachlan, F.R.S., kindly assisted in the classification of some of the more obscure pamphlets, and Miss Cora B. Sanders, of Lady Margaret Hall, in writing a number of slips.

In the latter part of the summer Mr. Holland arranged the large group of Danaine butterflies confined to tropical America and now separated as a distinct sub-family, the *Ithomiinae*. The immense growth of the Collection is well seen in this group. The whole of the specimens in the Department in 1893 were crowded into two drawers, and might have been expanded into five or six after the species had been worked out. Now that the Godman-Salvin and other accessions of less importance have been incorporated, with a fair allowance for future additions, the sub-family occupies sixty drawers.

During the remainder of the year Mr. Holland began to arrange the first part of the collection of Phytophaga (Coleoptera), which has been examined and named by Mr. M. Jacoby. A considerable part of this work has now been done, and early in 1899 the arrangement of the general collection of butterflies was resumed, that of the *Satyrinae* being already complete in 100 drawers, while the *Elymniinae*, *Amathusiinae*, and *Morphiinae* are worked out ready for the final arrangement. Making some allowance of space—viz. 40 drawers—for the *Pierinae* now being arranged by Dr. Dixey, the above-mentioned groups will, with those already arranged, occupy the whole of the 400 drawers recently ordered and delivered in November 1897 and March 1898. It is of the utmost importance that a further consignment, if possible of equal size, should be ordered forthwith, and during the six months which must elapse before the order is complete the final arrangement of the butterflies must be postponed and that of some other group undertaken.

Mr. A. H. Hamm has been chiefly occupied in setting and in printing labels for the additions to the Collection, especially the large number of specimens (over 3,000) brought by Prof. Poulton from Canada and the United States in September 1897. These specimens were captured, generally a few at a time, in so many different localities that the labour involved in labelling them has been very severe. He has also reset the butterflies, which have been arranged by Dr. Dixey and Mr. Holland in the general Collection, so far as they required it. The work upon the *Pierinae* arranged by Dr. Dixey has been especially troublesome, because of the flimsy condition of many of the older specimens.

Towards the latter part of the year Mr. Hamm arranged the Collection of British Hymenoptera Aculeata (ants, bees, wasps, &c.), which had been kindly named by Mr. Edward Saunders. A large amount of preliminary work upon these insects had been done by Miss Cecil Vernon Harcourt in the previous years. The Collection occupies 30 drawers, and is now in a most efficient state.

In addition to his work for the Department the Delegates employ one-fourth of Mr. Hamm's time in printing for the

Museum, and the Hope Collections have greatly benefited by the share which has been devoted to them. At these times labels in large type have been printed on the Museum press, and are now placed in the card-holders on the outside of cabinets and of drawers, thus facilitating reference to the Collections. This only applies to the parts of the Collection which have been finally arranged.

The immense additions made in 1897 have occupied so much time in setting, printing, labelling, cataloguing and incorporating, that those of 1898 and 1899 have necessarily been kept back. Even at the present date (June 1899) the 1897 additions are not all finished. In the meantime those parts of the additions of 1898 and 1899, which were specially needed in relation to the work which has been going on, have been labelled and incorporated. In spite of the great strain thrown upon our small staff by the 1897 accessions, I hope that we shall nearly have overtaken our arrears by the end of this year.

The Department has been greatly helped as in previous years by the kindness of friends. Col. Swinhoe has continued his work upon the Eastern moths. Dr. Dixey has continued the arrangement of the *Pierinae*, and has worked out many questions of the deepest interest, especially as regards the seasonal differences in many species, and the transitional forms which he has shown to occur connecting species which were believed to be distinct. Mr. Arthur Sidgwick and Mr. Pogson Smith have now arranged the British Lepidoptera as far as the middle of the Tortrices. Mr. M. Jacoby has continued his valuable examination of our collection of Phytophaga. Mr. Malcolm Burr (New College) has worked from time to time in the Department, and has often rendered kind assistance in the Orthoptera. Col. J. W. Yerbury visited the Department and rapidly surveyed the general collection of Diptera, upon which he wrote a very useful report, pointing out the groups in which the Hope Collections are especially strong, and giving a list of many of the important types which we possess.

Several distinguished entomologists visited the Collections in order to examine specimens in the groups in which they are authorities. Such work always does great service to the University in the better understanding of its Collections.

Dr. W. Horn of Berlin came to work at the *Cicindelidae*, Dr. Roeschke of Berlin at the *Carabidae*. Professor Roland H. Thaxter of Harvard University remained in Oxford for several days in order to work at the *Laboulbeniaceae*, a group of minute fungi which are parasitic upon certain beetles, &c. Mr. W. J. Lucas examined the British Odonata (Dragon-flies).

Many other eminent visitors paid a brief visit to the Department. Among these were Prof. Mitsukuri of Tökyo, Dr. Karl Jordan, H. Frühstorfer, Prof. Haswell, René Oberthür, Albert Fauvel, Aug. Lameere, and Rev. O. Pickard-Cambridge. F.R.S.

The annual visit of the Council of the Entomological Society took place on July 2–4. The President, Mr. Roland Trimen, Hon. M.A., F.R.S., the Treasurer, Mr. R. McLachlan, F.R.S., the Secretary, Mr. F. Merrifield, Mr. C. O. Waterhouse, Mr. M. Jacoby, Mr. J. W. Tutt, and Mr. A. H. Jones were present, and, as in the past, the Collections greatly benefited from the experience of our visitors. The members of the Council were entertained by Hope Curators and others interested in the Department. By the death of Mr. Osbert Salvin, F.R.S., who was with us in 1896 and 1897, and had been expected in 1898, the Hope Department has sustained a grievous loss. Mr. Salvin was not only a very generous donor to the Hope Department; we relied continually upon his deep knowledge, and immense experience in dealing with Natural History Collections.

I must again thankfully acknowledge the invariable kindness received in the Insect Department of the Natural History Museum and the Godman-Salvin Collection.

A considerable amount of scientific research has been published in the course of the year, describing work done in the Department or in some cases elsewhere upon material belonging to the Department.

The insects collected by Mr. E. N. Bennett, M.A., in Socotra (December 17, 1896, to February 11, 1897), were worked out: the Lepidoptera by Dr. F. A. Dixey, who described 2 new species, *Papilio bennetti* and *Byblia boydi*, the Orthoptera by Mr. Malcolm Burr, who described 1 new species, the Arachnida by Rev. O. Pickard-Cambridge, who described

4 new species. The paper appeared in Proc. Zool. Soc., 1898, p. 172.

Mr. Herbert Druce described 23 new species of South American moths (*Syntomidae*) in the Hope Collections (Ann. and Mag. of Nat. Hist., 1898, p. 401).

Dr. F. A. Dixey wrote on recent experiments on the hybridization of insects (Science Progress, April 1898), and on seasonal dimorphism in South American Pierine butterflies (Proc. Ent. Soc., December 7, 1898).

Professor Poulton published a paper on natural selection as the cause of Mimicry (Journal Linnean Society, 1898, p. 558), and in conjunction with Miss Cora B. Sanders attempted to obtain experimental evidence of the struggle for existence in certain insects (British Association Report, 1898, p. 906). The former paper describes many examples in the Hope Collections, the latter enquiry, aided by the Government Grant Committee of the Royal Society, was in part carried on in the Department.

The memoirs published in 1898 and 1899, together with others which appeared in the latter part of 1897, nearly suffice for a second volume of "Hope Reports," and it is hoped that the issue will take place before the close of the present year.

Additions to the Collection in 1897

(*imperfectly recorded in the Report of that year*).

It has been explained that the additions made in 1897 were labelled and catalogued only in small part when the Report of that year was issued in June 1898. Only about 1,600 specimens out of a total of about 12,000 had been catalogued and could be adequately acknowledged. The present Report begins where that of 1897 becomes brief and incomplete.

Rev. G. Dexter Allen presented 16 Lepidoptera Rhopalocera from the Alps and 10 Coleoptera from the Alps (with the exception of one from the Pyrenees).

Dr. E. Crompton and his brother, F. Crompton, Esq., presented a fine set of insects captured (1894–7) in the

neighbourhood of Victoria, Vancouver Island, comprising 74 Lepidoptera Rhopalocera, 121 Lepidoptera Heterocera, 6 Hymenoptera, 6 Diptera, and 3 Neuroptera. Dr. Crompton also presented the insects which he captured in September, 1897, during Professor Poulton's visit to Victoria, amounting to 48 specimens of many Orders, including one Arachnid.

Many other naturalists also presented specimens of insects captured at the same time in the same locality. Professor Meldola, F.R.S., presented 49 specimens of many Orders, Professor G. F. Fitzgerald, F.R.S., 23 specimens, Dr. Kirker, R.N., 4 specimens, Professor Sherrington, F.R.S., 3 specimens, E. A. Carew-Gibson, Esq., 19 specimens, and Professor Poulton 176 specimens. Eight specimens captured at an earlier date were presented by E. Baynes Reed, Esq.

Thus the Hope Collections have been enriched by over 540 specimens with excellent data from this interesting locality.

Professor Meldola presented 18 insects of various Orders, Professor Poulton 46 insects, and C. A. Ellis, Esq., 2 rare Coleoptera (*Carabidae*) from the neighbourhood of Vancouver.

An Acridian from Vernon, B.C., was presented by E. M. Walker, Esq., of Toronto.

Small numbers of insects of many Orders captured at various places on the Canadian Pacific Railway between Vancouver and Glacier House were also presented, viz. 31 specimens by Professor Poulton, 8 by Professor Meldola, and 1 by Miss Cecil Vernon Harcourt. The localities represented are Mission Junction, North Bend, Revelstoke, Albert Canyon, and Illecilliwaet.

Insects captured at or near Glacier House, on the summit of the Canadian Pacific in the Selkirk Range, at a height of from 4,000 to 6,000 feet were also presented—137 specimens by Professor Poulton, 23 by Professor Meldola, 11 by Miss Cecil Vernon Harcourt, and 1 by Professor W. Ramsay, F.R.S.

Thirty specimens from various localities between Glacier House and Lake Louise were presented by Professor Poulton, the places represented being Roger's Pass, Six-Mile-Creek, Beaver Mouth, Donald, and Palliser.

Twenty-three specimens from Lake Louise near Laggan, on the eastern slope of the Rockies at a height of from 5,550

to 5,700 feet, were presented by Professor Poulton, and 16 by Professor Meldola.

Five hundred and fifty-three specimens, captured in small sets at a very large number of localities on the Canadian Pacific and Grand Trunk Railways between Banff and Toronto, were also presented. The principal sets came from the following places, proceeding eastward from Lake Louise—Banff, Medicine Hat, Waldeck, Rush Lake, Parkbeg, Moosejaw, Regina, Brandon, Carberry, Rennie, Rat Portage and Nepigon. Of this number of specimens 8 were captured and presented by Miss Cecil Vernon Harcourt, 10 by Miss E. C. Ramsay, 14 by Mr. W. G. Ramsay, 9 by Professor Meldola, 3 by Professor G. F. Fitzgerald, 2 by Dr. W. Saunders of Ottawa, 4 by E. H. Chapman, Esq., of Magdalen College, 24 by E. M. Walker, Esq., of Toronto, and the remainder by Professor Poulton.

A very fine consignment of 633 insects of many Orders from Russell (W. Manitoba) was presented by Mr. H. R. Smith, late assistant in the Hope Department. They include over 400 specimens of Lepidoptera, several of which will be of much value for the series illustrating the subject of Mimicry.

One hundred and twenty-two insects from Virden (W. Manitoba) were captured and presented by Miss Mary G. Holmes. The specimens are beautifully collected and accompanied by excellent data.

Concerning the specimens from Southern Canada enumerated above, it may be well to point out that even the common species are very rare in European Collections. Thus Mr. H. R. Smith's valuable present included many specimens of two species of *Erebia* (*E. epipsodea* and *E. discoidalis*), which had never before been obtained further East than Calgary. Such a large number of specimens with excellent data from this part of the world forms an accession of the utmost value to the University Collections, and has also enabled us to enrich the British Museum with many of the duplicates.

Professor Poulton presented 234, and Professor Meldola 24 specimens of insects captured, in August and September, in the neighbourhood of Toronto. Professor J. Mavor, of Toronto, and his son presented 12 insects from the same locality.

Professor Poulton presented 42 insects from the river St. Lawrence between Quebec and Montreal, 129 from Quebec, and 40 from Montreal. Miss Cecil Vernon Harcourt presented 1 specimen from the latter locality.

A very interesting set of 41 insects of many Orders, captured July 1886 in Hudson Strait (Lat. 62° 35′ N., Long. 77° 22′ W.), was presented by F. F. Payne, Esq., of Toronto.

Miss Mary G. Holmes presented 69 insects from Ottawa.

Professor Poulton presented 26 insects from various localities in Ontario, and 150, and Professor Meldola 2, from Niagara Falls.

When not otherwise stated, all the captures in Canada were in the months July, August, or September 1897.

Professor Poulton presented 53 insects from Detroit, 274 from the neighbourhood of Chicago, and 287 from the neighbourhood of Hartland (Wis.); and in association with Professor W. M. Wheeler of Chicago University 182 insects, and with Professors Wheeler and S. Watasé 14 insects from the neighbourhood of Chicago. Professor Wheeler also presented 32 insects from the same locality, and 12 insects from various localities in the United States. The latter will be especially valuable for the Mimicry Collection.

Dr. G. W. Peckham presented 179 insects from the neighbourhood of Hartland (Wis.), and in association with Professor Poulton 12 from the same locality.

Twelve insects from Montana, U.S.A., were captured and presented by Mrs. W. Ramsay and her son and daughter.

With the exception of some of Dr. Peckham's (1896) and Professor Wheeler's (1895 and 1896) captures, all these specimens from the United States were taken in the same months of 1897 as those from Canada.

The interesting Collection of 102 insects from Socotra, captured 1896–7 by E. N. Bennett, Esq., M.A., has been already alluded to. Mr. Bennett also presented 1 specimen (*Papilio*) from Crete. One specimen (Hemipteron) from Tripoli was presented by A. J. Evans, Esq., M.A.

Professor Poulton presented 8 Lepidoptera captured in North America by his father in 1874–5, and a rare moth from the Naga Hills, Assam (1889).

Mrs. Bazett of Reading presented a useful set of 101 Lepidoptera, captured in 1893–4 in Switzerland (Vaud), and 28 from the Spanish Pyrenees (1892).

Mr. H. R. Smith presented 12 Lepidoptera from W. China, the Khasia Hills, Assam, and Europe.

Mr. A. H. Hamm presented 14 Lepidoptera from a variety of localities. These were especially useful in providing specimens which were much wanted from certain localities unrepresented in the Hope Collection, or of great interest in themselves.

Colonel Swinhoe presented a fine set of 248 Heterocera from the Khasia Hills, Assam (1893).

Mr. W. Holland presented 34 specimens (chiefly Lepidoptera) captured at various localities in Britain, to be added to the general collections.

Mr. A. H. Hamm similarly presented 30 specimens.

Rev. O. Pickard-Cambridge, F.R.S., presented a useful set of 68 insects, chiefly Lepidoptera, received from Rev. J. T. Roberts Rea from the Potaro River, Central British Guiana (1896).

Dr. F. A. Dixey presented 8 very interesting and valuable hybrid Saturnian moths, obtained by Dr. M. Standfuss, of Zurich.

Twenty-seven Lepidoptera, chiefly intended for the Mimicry Collection, were purchased from Messrs. Watkins and Doncaster.

The British Collections also received a very large number of accessions—by far the most important of recent years.

Rev. H. A. Harvey presented a specimen of a species of *Ichneumonidae* captured in Oxford.

A small but valuable set of 42 Hymenoptera Aculeata was presented by Edward Saunders, Esq., F.L.S., filling up some of the gaps in our fine British Collection of this Order.

Miss E. E. Thoyts presented a valuable set of 339 insects of many Orders captured by her chiefly in Sulhampstead Park, Berkshire. Two hundred and eighty-eight specimens of Hymenoptera were from the latter locality. All the specimens are accompanied by careful and excellent notes.

Mr. W. Holland presented a splendid set of 1,630 specimens, chiefly of Lepidoptera, from many localities, principally in the

neighbourhood of Reading. The data accompanying this great accession are excellent.

Mr. H. R. Smith presented, on his leaving England for Canada, a very fine set of 996 well-dated and localized specimens, also chiefly Lepidoptera from the neighbourhood of Reading.

Professor E. B. Poulton presented 1 specimen of *Tabanus bovinus*, another Dipteron, and 3 moths captured by him at Oxford in 1896 and 1897, and 136 specimens of Lepidoptera and 2 of Diptera captured, with only one exception, by him at Lulworth or Freshwater in July 1883; and his son, Edward P. Poulton, presented 2 rare moths captured by him (August 1897) at St. Helen's, Isle of Wight.

A specimen of *Sirex gigas*, captured in the Oxford Market in 1896, was brought to the Museum.

Mr. A. H. Hamm presented 167 specimens, mostly Lepidoptera, from the neighbourhood of Oxford, accompanied by excellent data.

Eighteen moths, captured in 1895 at Freshwater, were presented by W. M. Geldart, Esq., M.A., St. John's College.

One dragon-fly, captured at Oxford, was presented by Mr. Burden; and a wasp by Mr. H. Trim.

Colonel Swinhoe presented 1 bee, captured (1896) at Harpenden; Professor Poulton, 6 Hymenoptera Aculeata, captured at Great Malvern (1897); and Dr. Dixey, 1 beetle, taken in Oxford (1897).

The insects presented in 1897 have not been catalogued further than this point (about 9,700).

There still remain the following collections:—A valuable collection of many hundreds of insects brought by C. V. A. Peel, Esq., from Somaliland. These have received their printed labels, but cannot be catalogued until they have been worked out. Several new species and some new genera are now being studied by specialists in the various groups, and it is expected the memoir will be finished by the end of the summer.

A large and varied collection of butterflies and a few moths, chiefly from India and Burmah, presented by Colonel Swinhoe.

Many of these will be of great value in the Mimicry Collection.

A large collection, presented by Herbert Druce, Esq., F.L.S., consisting of butterflies from Africa and South America, and moths from Central America. These will be of great value to the general collections.

Dr. Dixey's important present of British Insects from the neighbourhood of Morthoe, N. Devon, is also at present uncatalogued.

Additions to the Collection in 1898.

The great strain thrown upon the Department by the accessions in 1897 has only permitted a small proportion of the specimens presented in 1898 to be as yet catalogued.

One of the most interesting additions made in recent years to the Department and the Museum is due to the kindness of Abbott H. Thayer, Esq., of Scarborough, N.Y., U.S.A., who prepared and painted models of two birds, illustrating the reason for the gradation of the colours of animals in nature —from dark on the back, through lighter shades, to white on the belly. These models show the difference between a uniform tint and colours so graded. In the latter case the increasing lightness is seen exactly to neutralize the increasing shade as the sides and under-surface of the animal are more and more shielded from the light of the sky in passing from the back to the belly. Furthermore the cold white light of the sky combined with the brown of the animal's back produces a colour-effect similar to that of the brown reflection from the earth combined with the cold white of its under-surface. The uniformly coloured model stands out in startling contrast beside the graded one which is inconspicuous and almost ghost-like, as so many animals are in nature.

The nest of a Marsh Warbler (*Acrocephalus palustris*) from Kingham, containing a cuckoo's egg buried under the lining, was presented by W. Warde Fowler, Esq., M.A. (Lincoln College). A nest of the Long-tailed Tit (*Parus caudatus*) was presented by G. Holding, Esq., M.A. (All Souls College). A nest of the Great Reed Warbler (*Acrocephalus turdoides*),

taken on the banks of the Guadalquivir by H. F. Witherby, Esq., was presented by him.

A valuable set of 51 insects of many Orders, chiefly Lepidoptera, captured in Mexico almost exclusively in 1897, and 71 captured in 1898, were presented by Osbert H. Howarth, Esq. Many of the specimens are of great value, and the data accompanying them most full and precise.

A valuable set of 175 insects, almost exclusively Lepidoptera, from Queensland (1897), Himalayas (1897), India (1897), Cape of Good Hope (1897), and Manila (1896), was presented by G. C. Griffiths, Esq.

Ninety-eight Lepidoptera from the Upper Engadine and the Upper Rhone Valley (1869) were presented by Rev. A. G. Butler, M.A. (Oriel College).

One hundred and two Lepidoptera from the South of France (1898) were presented by Colonel J. W. Yerbury. The data sent with the specimens are excellent.

Two Diptera from Arizona, captured (1897) with the 2 Hymenoptera they mimic, were presented by R. C. L. Perkins, Esq., B.A. (Jesus College).

Twenty-two insects from various localities in Palestine and Syria (1898) were presented by E. N. Bennett, Esq. M.A. (Hertford College).

Twelve valuable specimens of Orthoptera of various groups from Java, Celebes, and Ceylon (1889–96) were presented by Malcolm Burr, Esq. (New College).

The eggs of a Locustid from France (1897) were presented by W. J. Lucas, Esq.

A valuable set of 194 insects of many Orders, Arachnida and Myriapoda, from Manchuria (1898), was presented by R. T. Turley, Esq., and Mrs. Turley.

Two rare Coleoptera from Patagonia (1898) were presented by M. Jacoby, Esq.

Twenty-two Lepidoptera, with excellent data, from Mexico and Trinidad (1898) were presented by L. Richardson, Esq.

A pair of a rare Danaine butterfly from Madagascar (1891) was obtained by purchase from Messrs. Watkins and Doncaster.

The British Collections also received many accessions,

a relatively few of which have been catalogued and incorporated.

Seventy-two insects, captured in 1898 in various localities—Oxford, Berkshire (Sulhampstead Park), &c.—were presented by Professor Poulton.

An interesting variety of the male of *Pieris brassicae* from N. Devon (1897) was presented by Selwyn Image, Esq., M.A. (New College).

A fine specimen of *Bembex* from Oxford (1898) was presented by Miss Butler.

A series of 7 *Zygaena trifolii*, including some interesting varieties from Sussex, together with a pair of *Nyssia lapponaria* from Scotland, were presented by W. M. Christy, Esq.

Ten specimens, comprising dragon-flies and a few specimens of Orthoptera from various localities, all much needed by the Collection, were presented by W. J. Lucas, Esq., B.A.

In addition to the catalogued and incorporated specimens large numbers have been received in 1898, the majority of which have been set, while many have received their printed locality labels. These uncatalogued additions will now be briefly mentioned, and will be acknowledged in detail in next year's Report.

Very large and valuable additions, chiefly from tropical America, to the collection of moths have been made by Herbert Druce, Esq., F.L.S., and Col. Swinhoe has presented many Oriental moths from his own collection in the progress of his work in the Department: also a few butterflies from various localities.

The most important of all additions made in the year is, as has been already inferred, the captures made and presented by Guy A. K. Marshall, Esq., in S. Africa. These consist of a fine series of butterflies and Orthoptera, and a few insects of other Orders, from Salisbury, Mashonaland, and a few rare butterflies from Cape Town, and moths from Delagoa Bay. In addition to these great accessions to the general Collection, Mr. Marshall has made special collections to add to the series illustrating various zoological principles. Thus he has sent mimetic groups caught in one place on one day, and groups

of butterflies showing the attacks of birds or other enemies, such as the species of *Charaxes* with the "tails" bitten off the hind wings. But perhaps the most interesting and valuable gift of this kind is a set of specimens proving that *Precis octavia-natalensis*, a red and black butterfly with under side very similar to the upper side of the wings, occurring in the damp summer season, is only a seasonal form of the blue, black, and red *Precis sesamus*, a butterfly occurring in the dry winter, with an under side entirely unlike the upper, and with a wing of a different size and shape to that of *P. octavia-natalensis*. Mr. Marshall has sent two examples of the parent red form which laid the egg, and the blue offspring which he succeeded in rearing from it.

In the present year (1899) Mr. Marshall has further helped us by presenting a fine series of Coleoptera from Salisbury, and many other groups for the mimicry and other series, including one of unique interest from the extraordinary number and diversity of the forms which fall into it. All the specimens received from Mr. Marshall are set, and will soon receive their printed labels.

The most important addition that has yet been made to the rather poor set of European species contained in our Collections was due to a visit to Switzerland in July, 1898, made by Professor and Mrs. Poulton and Miss Cora B. Sanders. Many hundreds of specimens with very full data have been set, and will receive printed labels as soon as time will permit.

Very fine sets of Lepidoptera from Mexico and Queensland have been presented by G. C. Griffiths, Esq., in addition to those which have been described as already catalogued. We owe to Mr. Griffiths's kindness further sets from the same localities presented in the present year.

An interesting series of insects of many Orders, unfortunately in very bad condition, was brought from the Omdurman campaign, and kindly presented by E. N. Bennett, Esq , M.A. A brief account of the captures is printed in Mr. Bennett's recently published book on the campaign.

A small but valuable set of insects from Eastern Europe was presented by Malcolm Burr, Esq.

Dr. Dixey presented a large number of butterflies from Singapore.

Professor Poulton presented a few moths which emerged in Oxford during the course of the year 1898 from pupae obtained from larvae found by him in N. America the year before.

Miss Merivale presented a moth from Barbadoes, and 2 beetles from the River Niger were presented by B. Tomlin, Esq.

The British Collections have also been enriched by a large number of specimens which have not as yet been catalogued. Kind help is here briefly acknowledged from the following:— H. Trim, W. Holland, L. Clifford Brown, Dr. F. A. Dixey, A. H. Hamm, E. B. Poulton, R. W. Poulton, E. W. Blagg, Rev. E. C. Dobree Fox, W. J. Bruce, F. Bolton, F. Swanton, A. W. Daish, — Bartlett, A. G. S. Symonds, E. Wheal, J. Taylor, Mrs. Pelham, Miss Thoyts, Miss C. V. Butler, Miss E. M. Ramsbotham, Miss K. D. Mossman, and Miss C. B. Sanders. Full acknowledgment will be made in the Report of next year when the specimens will have been catalogued and incorporated.

Special mention must however be made here of the fine set of British Lepidoptera presented by H. Goss, Esq., F.L.S.

ADDITIONS TO THE HOPE LIBRARY IN 1898.

The Smithsonian Institution (United States National Museum, Washington) presented the publications which deal with the subjects of the Department.

The Boston Society of Natural History and the Bombay Natural History Society presented their publications for the year.

The University of the State of New York presented its Reports.

The Linacre Professor of Comparative Anatomy, Oxford, presented "The Linacre Reports," vol. iii.

The Radcliffe Librarian, Oxford, presented the Catalogue of Books added during 1897.

The Transactions of the Entomological Society, and the Transactions and Journal of the Linnean Society for the year 1898, were presented by Professor Poulton.

Canon W. W. Fowler presented three more parts of his

monograph on the Rhynchota Homoptera, vol. ii, in the Biologia Centrali-Americana.

The Agent-General for Queensland presented the "Annals of the Queensland Museum." No. I.

The National Museum of Rio de Janeiro presented its Journal, vol. i.

The Superintendent of the Museum of Zoology, Cambridge, presented the Thirty-second Annual Report (for 1897).

The Radley College Natural History Society presented its list of the Fauna and Flora of the district.

Sir John Evans presented the Memoirs of the Academy of Science, Bologna, series v, vol. vi, 1896–7.

Copies of original papers were presented by the following authors:—P. P. Calvert, Esq., of Philadelphia, Dr. A. G. Butler, Abbott H. Thayer, Esq., of New York, Dr. H. J. Hansen and William Sörensen. Frank Finn, Esq., Herbert Druce, Esq., Guy A. K. Marshall, Esq., Roland Trimen, Esq., Hon. M.A., F.R.S., and Dr. Karl Jordan.

Miss E. A. Ormerod very kindly completed the set of her valuable "Reports of Observations of Injurious Insects" in the Hope Library, presenting the 16th to the 21st for the years 1893 to 1898 both inclusive, and also the "Report" for 1884 which was missing from the earlier set. Miss Ormerod also presented the following volumes of which she is the authoress, "Handbook of Insects Injurious to Orchard and Bush Fruits, with Means of Prevention and Remedy," London, 1898, "A Text-book of Agricultural Entomology," London, 1892, and "A Manual of Injurious Insects," London, 1890. This kind present will be of great value to the important section of the Hope Library which deals with Economic Entomology.

"British Orthoptera," Huddersfield. 1897, was presented by the author, Malcolm Burr, Esq.

A few second-hand books were purchased together with the Zoological Record, the parts of Barrett's "British Lepidoptera," the Ray Society volume, and the parts of Rippon's "Icones Ornithopterarum" for the year.

EDWARD B. POULTON.

Report of the Hope Professor of Zoology.

The additions to the Hope Department during 1899 are very large and important, greatly surpassing those of 1898. Nearly 7,000 specimens have been already catalogued and incorporated, and large numbers can only be provisionally acknowledged on the present occasion. Mr. Guy A. K. Marshall's specimens from Mashonaland are, as on previous occasions, the most perfectly collected and valuable specimens received by the Department. Many of them illustrate problems of natural history of the widest interest, and form the evidence upon which the interpretation of several extremely difficult questions is to be sought. Other accessions are also of the highest importance, especially the valuable collection of moths collected by Cecil Barker, Esq., in Natal, presented by Roland Trimen, Esq., Hon. M.A., F.R.S.; of butterflies from Karwar, on the Malabar Coast, collected and presented by G. Keatinge, Esq.; and of butterflies from Sandakan, N. Borneo, collected by A. L. Cook, and presented by Herbert Druce, Esq., F.L.S. These, with the fine additions to the collections of British insects, mark the year 1899 as a very important one in the history of the Hope Department.

The final arrangement of the general collection of butterflies was continued by Mr. Holland, the *Satyrinae*, *Elymniinae*, *Amathusiinae*, and part of the *Morphinae*, being completed in 150 drawers. At this point the available cabinet space was exhausted, 40 drawers being kept in reserve for the *Pierinae*, which Dr. Dixey was arranging.

Towards a fund for the provision of new cabinets the Delegates of the Museum granted £50 to be paid in 1899, and £50 in 1900, and similar amounts were voted by Decree. A further consignment of 200 drawers was therefore ordered of Messrs. O. E. Janson & Son. Ten cabinets of 20 drawers each were completed and delivered in March of the present year, and the final arrangement resumed, the *Morphinae* and *Brassolinae* being completed, and considerable progress made with the immense group of the *Nymphalinae*.

Dr. Dixey continued the arrangement of the *Pierinae.* His chief work consisted in the completion of the arrangement of the extremely difficult genera *Colias* and *Terias.* The species are arranged in a most instructive manner to show the geographical and seasonal variations.

The arrangement of the Phytophaga (Coleoptera) so kindly worked out for the Hope Department by Mr. M. Jacoby, was next continued by Mr. Holland.

The classification is now complete up to the point reached by Mr. Jacoby, and the collection occupies 41 drawers in a cabinet of an old type with shallow drawers, not unsuitable however for these small beetles. A large amount of labour has been devoted to this collection, which is now in a very satisfactory condition.

Mr. A. H. Hamm has been chiefly occupied in setting and printing labels for the large number of accessions, and in resetting a large portion of the Lepidoptera which have been finally arranged. Many of these are very old specimens, in poor condition, and require the greatest care. During the Long Vacation he named and arranged the Syntomid Moths of the Department, following Sir George Hampson's recently published monograph.

Colonel Swinhoe completed the arrangement of the Oriental moths, thus finishing an arduous piece of work which has occupied him intermittently for many years. The working out and naming of this high proportion of our large collection of moths will be of the greatest value in the labour of bringing together the whole into one comprehensive series.

The arrangement of the British Lepidoptera has been continued by Mr. Sidgwick and Mr. Pogson Smith. The *Tortrices* are now complete, and the *Tineina* about half finished. Mr. Edward Saunders and Mr. R. C. L. Perkins visited the Department in the course of the year, and afforded valuable help in naming the most obscure among the recent additions to the British Hymenoptera. Dr. Frederick Moore kindly gave information as to the history of specimens formerly in the collection of the East India Company. Mr. Gilbert J. Arrow studied the section of Coleoptera he was at work upon

in the British Museum, and named many of our specimens. Mr. Roland Trimen kindly helped in the identification of many African butterflies. Mr. E. E. Austen looked through the general collection of Diptera, and made notes on some of the specimens. Mr. M. Jacoby continued his kind assistance with the Phytophaga.

The visit of the Council of the Entomological Society took place on July 1–3. Mr. Roland Trimen, Hon. M.A., F.R.S., Vice-President, Mr. R. McLachlan, F.R.S., Treasurer, Mr. J. J. Walker, R.N., and Mr. F. Merrifield, Secretaries, Mr. J. W. Tutt, and Mr. H. St. J. Donisthorpe were present.

Professor Meldola, F.R.S., Mr. Herbert Druce, F.L.S., Mr. Martin Jacoby, were also present, together with the Oxford students of the Insecta. The Hope Collections were inspected, and many interesting and useful suggestions made by the distinguished specialists who were present. The visitors were entertained by the Hope Curators and their friends. Mr. Arthur Evans kindly invited the party to Youlbury on the afternoon of July 2.

The collections have also been visited by many other eminent naturalists in the course of the year, including Mr. F. D. Godman, F.R.S., Hon. D.C.L., Professor L. C. Miall, F.R.S., Mr. W. L. Sclater, Mr. C. W. Dale, Mr. G. C. Griffiths, Mr. F. A. Heron, and Mr. W. J. Lucas.

I have much pleasure in acknowledging the great kindness of the members of the staff of the Insect Department of the British Museum of Natural History. It is a satisfaction that the Hope Department has been able to render some assistance by sending types for comparison with the specimens in the national collection.

As regards research upon the specimens in the Department, Mr. C. V. A. Peel's Somaliland insects were worked at by many eminent authorities in the various groups, and the paper was read before the Zoological Society in the beginning of the present year. The issue of "Hope Reports," Vol. II, is being deferred until this memoir can be included.

Professor Poulton, in association with Mr. F. Merrifield, brought out a paper in the "Transactions of the Entomological

Society," on the relation of the colours of pupae to the surroundings of the larvae, &c. Much of the recorded work was done in the Hope Department in 1898 and 1899, by Professor Poulton, assisted by Miss Cora B. Sanders, Miss Mabel E. Notley, and Miss Florence A. Wright. Observations of Mr. W. Holland and Mr. A. H. Hamm are also described in the paper.

The experimental inquiry into the struggle for existence in insects was continued by Professor Poulton, Miss Notley, and Miss Wright, aided by the Government Grant Committee of the Royal Society.

A large amount of work was involved in studying and making out the species contained in the collections illustrating mimicry and allied subjects made by Mr. R. Shelford, chiefly in Borneo, and by Mr. Guy A. K. Marshall, chiefly in Mashonaland. In this work Professor Poulton has received much kind help from the staff of the British Museum of Natural History, from Mr. R. McLachlan, F.R.S., and Mr. M. Jacoby.

Dr. F. A. Dixey, M.A., Wadham College, has undertaken a prolonged investigation into the secondary sexual characters of the *Pierinae.*

Mr. T. N. Annandale, B.A., Balliol College, investigated the insects and other forms brought by him from Siam, and commenced a paper upon various aspects of their natural history.

Additions to the Collection in 1896.

A valuable collection of 357 insects, chiefly Rhynchota, Hemiptera and Homoptera, from Sydney, Brisbane, New Zealand, and Java (1891–1893), was presented by Julius Langhans, Esq., Hertford College. In the press of other work, the setting, printing, and cataloguing was deferred until 1899. The specimens are now incorporated, and are a very welcome addition to the important collections by which these two Sub-Orders are represented in the Hope Museum.

Additions to the Collection in 1897.

(*Catalogued and incorporated since the issue of the last Report.*)

About 9,700 specimens presented in 1897 were recorded in the Reports for that year and for 1898.

The following additional donations have now been catalogued :—

Colonel C. Swinhoe, Hon. M.A., Wadham College, presented 250 Lepidoptera from a great variety of Oriental localities (various dates) and a few from America. Many specimens will be of value in the series illustrating Mimicry.

Mr. W. Holland presented a specimen of *Tirumala limniace* from Sikkim.

A valuable series of 150 butterflies from Sierra Leone (about 1890) was presented by Herbert Druce, Esq., F.L.S.

A small set of 27 butterflies from various localities was presented by C. V. A. Peel, Esq., F.Z.S.

The British Collections were also enriched by 321 specimens collected in 1897, with great care, by Dr. F. A. Dixey, M.A., Wadham College. Nearly the whole were captured near Morthoe, N. Devon, and all are accompanied by full and excellent data.

In addition to the above, Mr. Peel's large and valuable collection made in Somaliland in 1895 and 1897 is still waiting for the appearance of the memoir which has been written upon it, in order that references may be placed with the specimens. The paper is now in the Press, and will appear in the forthcoming Part I of the "Proceedings of the Zoological Society" for 1900, so that the incorporation of this fine collection cannot be delayed much longer.

The valuable collection of South American butterflies and Central American moths presented by Mr. Druce is also as yet uncatalogued.

Additions to the Collection in 1898.

(*Catalogued and incorporated since the issue of the last Report.*)

Only 835 specimens, presented in 1898, were recorded in the Report for that year. Since then much progress has

been made, and comparatively few specimens remain uncatalogued.

A very valuable set of 346 insects was presented by Guy A. K. Marshall, Esq., of Salisbury, Mashonaland. They consist of 266 Lepidoptera (263 butterflies and 3 moths), chiefly from Salisbury and other localities in Mashonaland (1895, 1897, and 1898), and a few from Delagoa Bay (1897), and Cape Town (1897); 3 Coleoptera, 4 Hymenoptera, 4 Hemiptera, and 69 Orthoptera, all from Salisbury (1898). The majority of the specimens are a most welcome addition to the general collection, but among them are many groups of even greater value, inasmuch as they illustrate various aspects of the natural history of insects. Thus there are many specimens showing the apparent attacks of birds or other enemies: butterflies with notched wings or with the tail-like prolongations of the hind wing (in the genus *Charaxes*) wanting and probably bitten off. Also groups of mimetic insects of many kinds captured on the same day, and specimens showing the parasitic attacks to which insects are subject. The specimens, like all those which we owe to Mr. Marshall's generosity, are beautifully collected, and are accompanied by extremely full data.

Mr. A. H. Hamm presented 36 Hymenoptera and Diptera from the neighbourhood of Oxford (1898), and a specimen of *Limnas chrysippus* from N. Borneo (1892).

A fine set of 114 Lepidoptera from Brisbane (1897, 1898) was presented by G. C. Griffiths, Esq. The specimens are in beautiful condition, many of them being bred specimens. In some cases Mr. Griffiths presented the pupae from which the butterflies emerged in the Museum. Mr. Griffiths also presented 39 Lepidoptera from Jalapa, Mexico (1893).

Seven bred specimens of Lepidoptera, together with 3 pupa-cases, and 14 Hymenoptera and Diptera from the neighbourhood of Oxford (1898), were presented by Mr. W. Holland (for the General Collection).

A set of 47 insects of many Orders from the Upper Nile near Khartum (1898), was presented by E. N. Bennett, Esq., M.A., Hertford College. Many of the specimens will be of considerable value on account of the locality.

A small collection of 35 insects, chiefly Lepidoptera, from South-Eastern Europe (1898), was presented by Malcolm Burr, Esq., New College. The localities render the specimens of special value to the Hope Collection.

Two Coleoptera from Lokoja on the River Niger (1896) were presented by Brockton Tomlin, Esq.

Colonel C. Swinhoe, Hon. M.A., Wadhâm College, presented 6 butterflies from various localities.

A hawk-moth from Barbados (1896) was presented by Mrs. Merivale.

A moth from the Adirondack Mountains (larva found 1891) was presented by Henry Balfour, M.A., Trinity College.

Professor Poulton presented 2 specimens of *Catocala elocata* bred in 1889 from European eggs, 2 specimens of a Smerinthine hawk-moth (with the pupa-cases) bred from larvae found in Vancouver Island (1897), a moth similarly bred from a larva found in Toronto, and 2 moths bred from larvae from Hartland, Wisconsin, in the same year.

Twenty-two Lepidoptera from South-East Mexico and Trinidad were presented by Lawrence Richardson, Esq.

Five British Lepidoptera for the General Collection were presented by L. Clifford Brown, Esq.

A very interesting collection of 99 specimens captured in 1898 in the neighbourhood of Urumiah (North-West Persia), and 2 moths from Kivorak (Transcaucasia), were presented by R. W. T. Günther, Esq., M.A., Magdalen College. The species have been described by experts in the respective groups in Mr. Günther's paper in the "Linnean Society's Journal," vol. xxvii, p. 345, and references to the appropriate page now accompany every specimen. The locality and exact data also render the accession of great value to the Hope Collection. Some of the specimens will be of special value for the series illustrating biological problems.

Mr. Günther also presented a collection of Lepidoptera made in the neighbourhood of Urumiah by the Rev. S. J. Daltry. These specimens have not yet been catalogued, inasmuch as it is hoped that further data may become available.

Professor Poulton presented 1,069 specimens and Mrs. Poulton 8 specimens of insects of many Orders captured in Switzerland (Valais and Bernese Oberland) in 1898. Many specimens are of value for the Biological Series.

Miss Cora B. Sanders, Lady Margaret Hall, presented 404 specimens captured in Switzerland at the same places and times as those last mentioned. Three specimens of *Papilio podalirius*, bred in Oxford from larvae found near Visp, were presented, together with their pupa-cases, by Miss Sanders and Professor Poulton.

This addition of nearly 1,500 Swiss specimens, mostly in excellent condition and with full data, is an important accession to the General Collection.

In addition to the above there remain uncatalogued a large and valuable collection of moths, chiefly from tropical America, presented by Herbert Druce, Esq., F.L.S.; a fine set of butterflies from Singapore, presented by Dr. F. A. Dixey, M.A., Wadham College; the latter are waiting in the hope of further data.

The British Collections have also received the following accessions:—Miss E. E. Thoyts presented 25 specimens of Lepidoptera, Hymenoptera and Diptera, from Sulhamstead Park, Berkshire (1898).

Four insects from Oxford (1898), 3 having been captured in the University Museum or its grounds, were presented by Mr. H. Trim.

A specimen of *Sphinx convolvuli*, captured in High Street, Oxford (1898), was presented by Mr. W. T. Bruce; another specimen, captured in Wellington Street, by Mr. F. Bolton; a third, captured at Youlbury, Boar's Hill, by Prof. Poulton; and a fourth from St. Helen's, Isle of Wight, was purchased from a boy.

Professor Poulton also presented 26 specimens of various Orders from Marlston (Newbury), Birdlip (1891), and St. Helen's (Isle of Wight), and Miss Cora B. Sanders 12 Diptera from the latter locality. Two Lepidoptera from St. Helen's were presented by Ronald W. Poulton, and 6 fine specimens of *Pyralis costalis* by Miss Sanders. All undated captures were made in 1898.

A fine specimen of *Acridium aegyptium* was captured alive in 1898 at St. Helen's, and presented by Mr. A. W. Daish. This specimen is of interest as bearing upon the introduction of insects into new countries.

Mr. W. Holland, of the Hope Department, presented 175 insects of various Orders from St. Helen's and the neighbourhood of Oxford (1898). They include a fine set of Hymenoptera, with the Diptera which mimic them, for the Biological Series.

A fine series of 12 *Zygaena minos*, captured in Wales (1896) by E. W. H. Blagg, was presented by Dr. F. A. Dixey, M.A., Wadham College, who also presented 66 insects of many Orders, from the neighbourhood of Morthoe, N. Devon, 10 from Lundy Island, 12 from near London (Coldfall Wood, East Finchley), and 8 from near Oxford (all 1898 except the latter, which are from 1893 to 1897). The specimens are rendered specially valuable by full and precise data. Two specimens of Hemiptera from Morthoe (1898) were presented by Giles Dixey. Dr. Dixey also presented 6 British butterflies from various localities (1876–97), showing the apparent attacks of birds.

Thirteen butterflies from near London (Wandsworth) and the Isle of Wight were presented by L. Clifford Brown, Esq.

Mr. A. H. Hamm, of the Hope Department, presented 337 insects of various Orders from the neighbourhood of Oxford, S. Devon, and Wellington College, all captured in 1898, and one captured at Basingstoke about 1888. Many Hymenoptera and mimetic Diptera captured on the same day will be valuable for the Biological Series, together with specimens set in the attitude of rest, and others showing the apparent attacks of enemies.

Four specimens of *Caradrina ambigua* from S. Devon (1897) were presented by the Rev. E. C. Dobree Fox, together with a specimen of *Lycaena aegon* from Westmorland (1897).

A female specimen of *Gonepteryx rhamni*, found hybernating on Dec. 30, 1898, was presented by Mrs. H. F. Pelham, Trinity College.

Mr. Joseph Walker, of the Radcliffe Library, presented a queen wasp found hybernating in the University Museum on Dec. 13, 1898.

A fine set of 327 specimens of Lepidoptera from various British localities was presented by Herbert Goss, Esq., F.L.S. The specimens are in very fine condition, and were captured or bred at various dates by Mr. Goss himself. They form a very welcome accession to the collection of British Lepidoptera.

Miss E. M. Ramsbotham and Miss K. Mossman presented 6 cast skins of a species of *Perla* from Yorkshire (1898).

A species of *Cassida* from Enslow Bridge (1898) was presented by A. M. Bell, Esq., M.A., Balliol College.

The cocoon and pupa-case of *Procris geryon*, from Birdlip (1898), was presented by Miss C. V. Butler.

A fine specimen of *Arctia caja* from Oxford (1898) was presented by Mr. J. Taylor.

Five specimens of *Crabro interrupta* were bred (1898) from some rotten wood containing their pupae. Presented by Miss Ward. From Oxford.

Miss Cora B. Sanders and Prof. Poulton presented the pupa of *Vanessa urticae*, with the parasitic *Tachina* which emerged from it, and the puparium of the latter.

Miss Sanders presented 12 bred specimens (1898) of the third brood of *Pieris brassicae*. Four of these are for the General Collection.

A pair of *Endromis versicolor*, captured in Kent about 1868, was presented by the Rev. A. G. Butler, M.A., Oriel College.

Additions to the Collections in 1899.

Very large accessions have been made in the year 1899, and although nearly seven thousand specimens have already been catalogued, large numbers are still waiting, and can only be provisionally acknowledged on the present occasion.

A pair of *Colias hecla* from Greenland, and 99 specimens of the genus *Erebia* from various localities, representing nearly the whole of the species, were presented by H. J. Elwes, Esq.,

F.R.S. These latter were of great value in working out the species of this important group of mountain butterflies, upon which Mr. Elwes is the recognized authority.

An invaluable collection of 495 insects from Mashonaland, nearly all from the neighbourhood of Salisbury, and 2 from near Durban, Natal, were presented by Guy A. K. Marshall, Esq. The General Collection has been enriched by an important addition of specimens, in beautiful order, and with more complete data than almost any others in our possession. Furthermore a large number of specimens represent the material which Mr. Marshall has specially collected, in order to work out and illustrate various biological problems of the utmost interest.

Thirteen examples of *Precis sesamus* were in reality presented in 1898, and are briefly referred to in the Report of that year. They were however inadvertently omitted from the catalogue of Mr. Marshall's donations in 1898, and are therefore included in those of 1899. These specimens are historic, for they constitute the evidence of the most wonderful known example of seasonal dimorphism, proving that the red and black *Precis octavia-natalensis* is the summer form of the blue, black, and red *P. sesamus*, a butterfly which flies in the comparatively dry winter, and differs from the former in habits, pattern, size, shape of wing, and in the relation of the colouring of the under side to that of the upper side of the wings. The series contains specimens of the former captured at the end of summer, and of the latter at the beginning of winter, 1898 (a fourteenth specimen, of *octavia*, captured in 1899 carries the sequence on for another season), as well as two female specimens of *P. octavia-natalensis*, and butterflies of the other form obtained from the eggs which they laid. A beautiful photograph of the whole group, taken by Mr. Alfred Robinson of the University Museum, is now at the Paris Exhibition.

Mr. Marshall also presented many groups illustrating Mimicry and Common Warning Colours among insects.

A group of 18 specimens of 5 very similar species of *Acraea*, captured on one day, illustrates the tendency of the insects of specially protected groups to assume a similar appearance.

Another smaller group of 4 specimens showed the same tendency to be strongly marked in two larger species of *Acraca* (*A. anemosa* and *A. natalica*), also captured on the same day.

A specimen of *Teracolus phlegyas* (female) subjected to damp heat in the pupal condition.

Twenty butterflies showing injuries probably caused by the attacks of enemies.

Five beetles taken almost uninjured from the crop of a guinea fowl (*Numida coronata*).

A large convergent group of 45 insects of various Orders, all red-brown in colour with a black patch on the posterior part of the body or wings. The appearance is evidently mimetic of Lycid beetles, of which several species are included. The group comprises many beetles in addition to the *Lycidae*, many *Hymenoptera*, a fly, two moths, and a bug.

Other interesting groups are—9 small beetles with a very similar appearance (type of pattern that of the included *Phytophaga*); 24 large beetles with the pattern most characteristic of the *Cantharidae*; also small groups exhibiting resemblance between Coccinellid beetles and a bug (4 specimens); an Ichneumon, a beetle, and a bug (3 specimens); wasps and an Ichneumon (3 specimens); 4 pairs, each consisting of a different species of stinging Hymenopterous insect and a mimetic fly; 13 specimens of *Mutillidae*, spiders and beetles with a similar colouring; 2 large species of *Carabidae* (3 specimens), with very similar apparently warning markings produced in quite different ways; 16 beetles of various groups with a similar type of colouring.

Many of these examples are new species hitherto undescribed. In addition to the above, Mr. Marshall has sent a magnificent new fly of the genus *Hyperechia*, mimetic of an African xylocopid bee.

The 2 specimens from Natal (1897) are bugs of entirely different groups, and yet with an almost identical pattern and colouring.

I have described this especially valuable material at length, but we also owe to Mr. Marshall's generosity important

additions to the General Collections, including 3 Hymenoptera, 2 Hemiptera, and a very fine collection of 295 Coleoptera, all from the neighbourhood of Salisbury (1898, 1899), and a further fine set of Lepidoptera which arrived later, and have not as yet been catalogued.

A fine set of 205 specimens of *Limnas chrysippus* and some allied forms, from various localities in Afghanistan, Baluchistan, and India (1879–83), was presented by Mr. W. Holland. The specimens are from the Collection of Colonel Swinhoe, Hon. M.A., Wadham College, and are a valuable addition to that important department of the Hope Collection which deals with variation of species in relation to geographical distribution.

Five specimens of *L. chrysippus*, and an allied form, from Greece and various localities in the eastern part of its range (1877–92), were presented by J. J. Walker, Esq., R.N.

A fine set of 234 Lepidoptera, in beautiful condition, from the neighbourhood of Brisbane (1897, 1898)—170 from Jalapa, Mexico (1893); and 15 from various localities in tropical S. America (1896, &c.)—was presented by G. C. Griffiths, Esq.

A specimen of *Anosia plexippus* and its mimic *Limenitis misippus*, captured on the same day (July 26, 1899) at Lake Simcoe, Ontario, were presented by E. M. Walker, Esq., of Toronto.

A set of 180 butterflies from Ashanti (1896) was presented by Captain the Hon. Grosvenor Hood. The suggestion was kindly made to Captain Hood by the authorities of the British Museum (Natural History). The specimens will be of great value to the Hope Collection on account of the locality—Cape Coast Castle to Kumassi.

Ninety Lepidoptera, Hymenoptera, and Coleoptera, from Virden, Manitoba (1898), were presented by Miss Mary G. Holmes. The collection includes specimens for the Mimicry Series, and all the insects are accompanied by the fullest data.

A very valuable collection of 700 butterflies from Sandakan, Borneo (1895–96), was presented by Herbert Druce, Esq., F.L.S. This fine series is a very welcome addition, the majority of specimens being in beautiful condition; many

specimens will be of value for the Mimicry Series. Mr. Druce also presented 5 specimens from other localities in Borneo (1895–96).

A fine collection of 772 insects of many Orders from the Towranna Plains, W. Australia (1898), was purchased from E. Clement, Esq., Ph.D. Dr. Clement kindly permitted a selection of the specimens required by the Department for a very moderate remuneration. The collection is especially rich in moths, but also includes a fine set of Australian wasps for the Mimicry Series.

Nineteen moths from St. Helen's, Isle of Wight (1899), were presented to the General Collection by Mr. W. Holland and Mr. A. H. Hamm, and 81 insects of various Orders from the same locality by Mr. Hamm.

A valuable collection of 162 insects from Nairobi, and between Nairobi and Mount Kenia, British East Africa (1899), was presented by H. J. Mackinder, Esq., M.A., Christ Church, and C. B. Hausburg, Esq. The specimens were excellently collected and with full data. They include some species which are new to science, and all are of great value to the Hope Collection, on account of their rarity or the fact that they are unrepresented from this interesting locality.

One of the most important accessions of recent years is the generous gift of a fine collection of butterflies, containing 805 specimens, from Karwar, Bombay Presidency (1894–97), by G. Keatinge, Esq. Large numbers of the specimens were bred from the larvae, and almost all are in the most beautiful condition, with data far superior to all but a few of our Indian insects.

Lady Denton presented a scorpion and a Cicada from Ilaro, near Lagos Island, W. Africa (1899).

The Rev. G. B. Simeon presented a specimen of *Anosia plexippus* from Hawaii (1885).

Sixty butterflies from Switzerland, Valais (1899), were presented by H. M. Wallis, Esq.

Thirty-two insects of various Orders from Switzerland, Valais (1897), were presented by Mrs. E. C. Bazett.

Two moths from the Khasia Hills, Assam (1890–96), were presented by the Rev. G. Dexter Allen, B.A.

Three butterflies from the Oriental Region (1890–96) were presented by Mr. W. Holland.

Seven butterflies and a moth from various localities were presented by Col. Swinhoe, Hon. M.A., Wadham College.

A fine collection of 293 butterflies, moths, and other insects, from Ecuador (1896–97), was purchased from Mr. W. F. Rosenberg. Many of these will be of great value for the Mimicry Collection.

The collection of Phytophaga has been enriched by 1,475 specimens selected from the duplicates of the British Museum (Natural History). Nearly the whole of these have been named and placed in the part of the collection which is now completely arranged.

In addition to the accessions recorded above, a large number still remain uncatalogued, and are now provisionally acknowledged.

The Curators of the Indian Institute presented the collection of insects formerly in the Museum of the East Indian Company, together with the cabinets in which they were contained. Although the condition of the majority of the specimens is poor, many of them will be of value to the Hope Collection.

The British Museum of Natural History has presented a very large number of butterflies selected from among their duplicates.

The very fine collection of S. African moths made by Cecil Barker, Esq., of Malvern, Durban, Natal, was presented by Roland Trimen, Esq., Hon. M.A., F.R.S.; also butterflies from S. Europe.

E. S. Goodrich, Esq., M.A., Merton College, presented the insects captured by him in Ceylon (1899), accompanied by excellent data.

Herbert Druce, Esq., F.L.S., presented a fine collection of moths chiefly from Central America.

Dr. T. A. Chapman presented a valuable set of Lepidopteras, chiefly Erebias, from Switzerland and Norway.

A collection of butterflies from Banff, Canada, was presented by H. J. Elwes, Esq., F.R.S.

Five butterflies captured at sea and Lepidoptera from various European localities were presented by J. W. Tutt, Esq.

A very fine series of Lepidoptera was collected in Siam by Richard Evans, Esq., B.A., Jesus College. Mr. Evans proposes to work them out in the Hope Department, and will present many of the specimens to the Hope Collection.

A large number of insects of various Orders were presented by G. C. Griffiths, Esq., from Japan, Sumatra, the Moluccas, the Khasia Hills and other Indian localities, Zomba, N. Queensland, Mexico, Switzerland.

Colonel J. W. Yerbury presented a fine collection of Diptera (*Syrphidae*) made by him at Aden. This valuable collection includes many types. He also presented specimens of Diptera for the British Collections, and examples of Diptera resembling Hymenoptera for the Mimicry Series.

A fine series of insects, chiefly from British North Borneo, illustrating mimicry, and allied subjects, was presented by R. Shelford, Esq., B.A. (Cantab.), of the Sarawak Museum, British N. Borneo. Mr. Shelford also presented a very fine series of insects from the same district for the General Collection.

Small collections of insects from the localities indicated were also presented by the following donors:—From Uganda, by Mrs. Bazett; from Switzerland, by Hugh Richardson, Esq.; from Norway, by E. N. Bennett, Esq., M.A., Hertford College; from various localities, especially W. Africa, by Mark L. Sykes, Esq.; from the United States, by Abbott H. Thayer, Esq.; from Fiji and Vancouver, B.C., by Professor Gilson; from Darjeeling, by Henry Ward, Esq.; from Europe, by D. Chaplin, Esq., M.A., University College; from Sylhet, by W. Hatchett Jackson, Esq., M.A., Keble College; from Mexico, by Osbert H. Howarth, Esq.; from Brittany, by Professor Poulton, M.A., Jesus College; from Vancouver

Island, by Mr. A. H. Hamm; from California, by Ronald W. Poulton; from Europe, by F. Merrifield, Esq.; and from Europe, by Professor R. Meldola, F.R.S.

The additions to the collections of British Insects in 1899 have been very numerous and valuable, due especially to a week's visit of the staff of the Department to St. Helen's, Isle of Wight, at the beginning of July, 1899. As a result of untiring work the following specimens have been incorporated. Mr. W. Holland presented 243 insects, chiefly Coleoptera, many of them of great rarity, exclusive of a large number which he will add at a later period. Mr. A. H. Hamm presented 587 insects, chiefly Hymenoptera, many being very rare and interesting species. Together they presented 68 moths. Professor Poulton also presented 19 insects, while 9 others were given by all three naturalists. All the specimens have very full data, and are a most important accession. Many specimens will be added to the series illustrating the natural history of insects.

A wasps' nest found at Headington Hill (1898) was presented by Hugh F. Hall, Esq.

An interesting specimen of a large locust (*Acridium aegyptium*) was presented by Mr. J. Gee, having been introduced into Oxford from Italy in broccoli. The insect was alive when brought to the Department (Feb. 8, 1899).

A pair of very rare Hymenopterous insects (*Astata stigma*), from Brandon (1898), was presented by R. C. L. Perkins, Esq., B.A., Jesus College.

Thirty-nine insects were presented by J. J. Walker, Esq., R.N., including rare Coleoptera from Kent and S. Devon (1898–9), 3 *Colias Hyale* from Sheppey (1899), and 25 Lepidoptera from the neighbourhood of Rannoch (1899).

Eighty Lepidoptera, captured by Mr. William Reid in N. Shetland and various localities in Scotland (1895–98), were presented by G. C. Griffiths, Esq., together with a pair of the rare *Platypteryx sicula* (1899), confined in this country to the Leigh Woods, Bristol.

A dragon-fly from the neighbourhood of Oxford was presented by Dr. F. A. Dixey, M.A., Wadham College.

Two wasps and a mimetic fly captured at Dorking, on the same flower-heads, were presented by Edward Saunders, Esq., F.L.S.: for the Mimicry Series.

Many further accessions to the British Collections have not yet been catalogued.

A set of moths from N. Cornwall were presented by A. G. Cardew, Esq., M.A., Queen's College. A valuable set of rare British Hymenoptera, filling up many gaps in the Hope Collection, was presented by Edward Saunders, Esq. British Coleoptera, with excellent data, and many of them very rare species, were presented by Horace St. J. Donisthorpe, Esq.

Small numbers of British insects were also presented by the following donors:—Mrs. A. G. Butler, Miss Ruth Butler, Miss C. V. Butler, Miss Janet Poulton, Miss C. B. Sanders, Miss Mabel E. Notley, Miss F. A. Wright, Professor E. A. Minchin, Professor E. B. Poulton, Major R. B. Robertson, Mr. Henry Higgs, Mr. W. Holland, Mr. C. J. Bayzand, Mr. A. Overington, Mr. A. H. Hamm, Mr. Edward Webb, Mr. A. Drew, Mr. A. Robinson, Mr. H. Trim, and Ronald W. Poulton.

ADDITIONS TO THE HOPE LIBRARY IN 1899.

The Trustees of the British Museum presented the "Catalogue of the Lepidoptera Phalaenae," vol. i., by Sir George F. Hampson.

The Smithsonian Institution (United States National Museum, Washington) presented the publications which deal with the subjects of the Department.

The Boston Society of Natural History and the Bombay Natural History Society presented their publications for the year.

The University of the State of New York presented its Reports.

The Linacre Reports, vol. iv, were presented by Prof. E. Ray Lankester, F.R.S.

The Radcliffe Librarian, Oxford, presented the Catalogue of Books added during 1898.

The Transactions of the Entomological Society, and the Transactions and Journal of the Linnean Society for the year 1899, were presented by Professor Poulton.

"Fauna Hawaiiensis," vol. i, part 1, and vol. ii, parts 1 and 2, were presented by the author, R. C. L. Perkins, Esq., B.A., Jesus College.

"Colouration in Animals and Plants," and "On the Growth of Trees, &c.," by the late Alfred Tylor, Esq., F.G.S., were presented by Mrs. Alfred Tylor.

Miss E. A. Ormerod presented her valuable "Report of Observations of Injurious Insects, &c.," for 1898 (22nd Report), and for 1899 (23rd Report).

Copies of original papers were presented by the following authors:—Herbert Druce, Esq., F.L.S.; W. F. Kirby, Esq., F.L.S.; H. J. Elwes, Esq., F.R.S.; Dr. A. G. Butler; Rev. T. R. R. Stebbing, M.A., F.R.S., Worcester College; S. H. Scudder, Esq.; R. W. T. Günther, Esq., M.A., Magdalen College; Horace St. J. Donisthorpe, Esq., F.E.S.; G. W. Kirkaldy, Esq., F.E.S.; G. C. Bignell, Esq., F.E.S.; Professor Roland Thaxter, Harvard Univ.; and Sir George F. Hampson.

A large and valuable set of original papers has been presented by Lionel de Nicéville, Esq., F.E.S.

The Committee of the Bristol Museum presented their Report for 1896–98.

A paper on the Collembola, &c., of Devon, by Edward Parfitt, was presented by F. J. Haverfield, Esq., M.A., Christ Church.

A few second-hand books and papers were purchased, together with the Zoological Record, the parts of Barrett's "British Lepidoptera," the Ray Society volume, and the parts of Rippon's "Icones Ornithopterarum" for the year.

EDWARD B. POULTON.